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THE ELECTRICIAN:

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NOTES.

Electric Lighting in Boston (America).—It is stated that the city of Boston intend to spend 83,000 dollars in electric lighting this year.

Postal Telegraph Appointment.—Mr. J. Clarke, sorting clerk and telegraphist at Winchester, has been appointed postmaster of Basingstoke.

Cricket.—On Whit Monday Messrs. Siemens Brothers played R. E. Crompton and Company at cricket, and the latter won by one innings and 108 runs.

Provisional Order Abandoned.—The Metropolitan Brush Electric Light Company have abandoned their Provisional Order for Camberwell and Penge.

Electric Light Wires in Pittsburgh, U.S.—The Fire Marshal of Pittsburgh has inspected the electric light wires in that city, and reported them to be perfectly safe.

The Telephone in Paris.—The Western Railway Company of France have just connected their termini at Saint-Lazare and Montparnasse with the chief municipal offices of Paris.

The Edison System in Baltimore.—The offices of the *Sun* newspaper in Baltimore, U.S., are lighted by Edison's incandescent system. In a recent issue this paper speaks in high terms of the lights.

Anglo-American Brush Corporation.—Lord Thurlow has accepted the chairmanship of this corporation, and Mr. Herbert C. Gibbs, of the firm of Messrs. Antony Gibbs and Sons, has also joined the board.

Lewisham.—The Metropolitan Brush Company have withdrawn their application to light the district of Lewisham, but have expressed a hope that the district board of works will grant them permission to do so next year.

Electric Lighting for Lambeth.—The Lambeth Vestry have given notice of their intention to apply, under the Electric Lighting Act, for a license "to construct and maintain electric lines and works and to supply electricity within the parish."

The Zanzibar and Mozambique Cable.—The Eastern Telegraph Company announce the repair of the Eastern and South African Telegraph Company's cable between Zanzibar and Mozambique, thus re-establishing telegraphic communication with the Cape of Good Hope and Natal.

Society of Telegraph Engineers.—The next meeting will take place at 8 p.m. on Thursday, the 24th inst., at 25, Great George-street, S.W., when the following paper will be read:—"On the Cause of Magnetism" (illustrated by experiments). By Professor D. E. Hughes, F.R.S., vice-president.

Electric Lighting for Westminster.—The Electric Lighting Committee of the St. James's (Westminster) Vestry have recommended that the Edison Company should light the whole of the parish, it being desirable that there should be no conflicting interests between different companies. This recommendation has been adopted by the vestry.

A Change of Title.—We notice that our contemporary *Electric Light* has changed hands, and that its new proprietors have thought fit to alter its title to that of *The Electrical Engineer.* Concurrently with this change we notice that the price of each issue has been reduced from 6d. to 3d. We wish our contemporary all success and a prosperous life.

The Submarine Cables Trust.—With £1,837 brought down, the revenue of the Submarine Cables Trust for the year was £23,901, out of which the expenses of the Trust for that period, amounting to £1,333, and two half-yearly coupons at the usual rate of 6 per cent. per annum, absorbing £20,382, have been paid. The sum left to be carried forward is £2,185.

The Scandinavian Electric Company.—Mr. J. E. Costello, the liquidator of this company, has given notice to the effect that the affairs of the company being now fully wound up, a general meeting will be held on the 15th June, at 12 noon, at 20, Bucklersbury, E.C., when an account will be submitted showing the manner in which such winding-up has been conducted.

Appointment.—Mr. Hugo Pischon, who in 1874 introduced the Pintsch system of lighting railway carriages and steam ships into England, and who remained for some years managing director of the Pintsch Patent Lighting Company in London, has been appointed assistant managing director by the German Edison Company of Berlin, which has been lately established.

Hygienic Exhibition in Berlin.—This exhibition was opened on Thursday, 10th May. It is lighted by electric light, and both telegraph and telephone offices are to be found in the building. Siemens arc lamps illuminate the square in front of the building, whilst a large concert hall inside is lighted by Edison's system. A model coal mine is also lighted up by Siemens and Halske arc lamps.

The "Operator."—The *Operator* of New York, which lately assumed the sub-title of *Electrical World* in addition, has now reverted to its old and original title, whilst the *Electrical World* has been launched as a separate paper. The *Operator* will be devoted, as in its earlier days, exclusively to telegraphy, whilst the *Electrical World* will have a wider scope. The latter will appear weekly, but the former bi-monthly only.

The Telephone in Sheerness Dockyard.—It has been

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decided by the authorities of Sheerness Yard to establish telephonic communication between the bell stand and the ticket office, so that immediately the bell is rung for the last time the issue of tickets will be suspended, and those who have not passed through the office, even although they may have entered the dockyard gates, will have an eighth deducted from their day's pay.

Opera by Telephone.—An interesting experiment was tried the other evening by the management of the Savoy Theatre for the amusement of the Prince of Wales and other guests of Mr. Arthur Sullivan. A special wire having been laid on to Mr. Sullivan's private residence, Queen's Mansions, the principal songs and choruses of "Iolanthe" were sung upon the stage by Miss Barnett, Mr. Rutland Barrington, Mr. Temple, and transmitted by telephone.

Prevention of Fires.—A public meeting will be held at the Society of Arts on the subject of the prevention of fires in theatres. The report of a committee of the society, which has for some time been investigating the question, will be brought before this meeting for its consideration. The precise date has not yet been decided, but it will be held the end of the present month. Further particulars will appear in future numbers of the Society of Arts' *Journal*.

Oriental Telephone Company.—Subject to final audit, the directors of this company will, at the annual general meeting to be held on the 30th inst., after carrying £7,000 to reserve fund, and replacing to capital the outlay on exchanges sold, recommend a final dividend of 2½ per cent., making, with the interim dividend already paid, a total distribution of 5 per cent. for the year ending December 31, 1882. The sum of £709 4s. 8d. is carried forward.

Electric Lighting at Chesterfield.—The Committee of the Chesterfield Town Council, appointed to consider the electric lighting arrangements in the town, which have now been in existence for some time past, have reported that the lighting of the streets has been completed to their satisfaction. In accordance with this report the town council have decided to enter into a permanent contract with the Hammond Electric Light Company, by whom the work has been carried out.

Great Western Electric Light Company.—A notice appeared in the *London Gazette* of May 1, to the following effect:—"A petition for confirming a resolution reducing the capital of the above company from £250,000 to £195,000, was, on the 3rd day of May, 1883, presented to Her Majesty's High Court of Justice, and is now pending, and the list of creditors of the company is to be made out as for the 15th day of June, 1883." The notice is signed by Messrs. Ashurst, Morris, Crisp, and Co., 6, Old-jewry, E.C., solicitors for the company.

Bootle Town Council and Electric Lighting.—The Town Council of Bootle, near Liverpool, some time since appointed a committee to visit the works of the Electric Carbon Storage and Apparatus Manufacturing Company of Scotland. This committee presented their report at a meeting of the council held last week. They suggested that, if the council entertained the matter at all, the company should be allowed to submit an estimate for lighting the Town Hall. After a little discussion the report was accepted, and the matter postponed.

The Telephone in Buenos Ayres.—We recently announced that the rival telephone companies in Buenos Ayres had decided to join hands. Since then the United Telephone Company of the Rio de la Plata, as the combined interests are now called, has issued the first list of subscribers to its Buenos Ayres Exchange. It appears that these already numbered close on to 1,000 on the 1st of April, and that the rate of increase is very large. The company have just received a large instalment of telephone cables and exchange apparatus, and seem to be going ahead.

Electric Lighting in Bombay.—The shop of Messrs. Treacher and Co. in Bombay has been lighted on the incandescent system by the Eastern Electric Light and Power Company. Fifty Swan lamps are used, the current being supplied by twenty accumulators. The same company have contracted with the Government to light the High Court, the Esplanade, the band stand, and several roads in the city. The company's charging stations are at Mody Bay and Tardes, and their work is being carried out under the superintendence of Major Strutt, managing director, and Mr. Grindle, electrician.

Telegraph Materials and Instruments Wanted.—The Caledonian Railway Company are inviting tenders for the supply of india rubber, iron wire and strand (galvanised), signal fittings, telegraph instruments, &c., for twelve months from the 1st of July next. Specifications and forms of tender, and any other necessary information, may be obtained from Mr. William Haig, superintendent of stores, Caledonian Railway, St. Rollox, Glasgow. Patterns may be inspected from 9 a.m. till 5 p.m., at the Stores. Tenders, endorsed "Tender for Stores," to be lodged with the Secretary, 302, Buchanan-street, Glasgow, not later than 28th inst.

The Maxim-Weston Electric Company.—A correspondent has kindly forwarded to us a circular relating to this company, signed by Hugh Watt. It is extremely difficult to criticise a managing director's figures, but at the same time it is singular to find a company said to be making £200 a week profit anxious to issue fresh capital under the conditions put forward at the recent meeting. We should have thought that under such circumstances money would have been only too easily obtained. We have heard that the reorganisation mentioned in this circular has consisted in getting rid of most of the men who knew anything of their work.

The Paris International Electrical Congress.—Professors Trowbridge, of Cambridge, Mass., Rowland, of Baltimore, and Barker, of Philadelphia, visited the Department of State at Washington on the 19th April, to arrange the details of the electrical experiments to be conducted on the part of the United States with reference to the international conference to be held at Paris next October. It was arranged, says the *Electrical World* of New York, that Professor Rowland should conduct the experiments to determine the standard of electrical resistance, Professor Trowbridge the experiments relating to atmospheric electrical disturbances, and Professor Barker those which look to the determination of a standard of light.

Leeds and the Electric Light.—It is understood that the experimental lighting authorised at their last meeting by the Leeds Town Council will embrace the lighting of the Victoria Hall and vestibule, and the erection of arc lamps in Victoria-square; also the lighting of certain portions of the new Public Offices, namely, the office on the ground floor where all the rates and rents due to the corporation will be paid, the large clerks' room adjoining, the lending library, the reference library, and the reading room; and the placing of arc lamps in front of the offices in Calverley-street. It is probable that the shed in the new fire brigade station will be utilised for the engine and dynamos. The intention is, we believe, to invite tenders for the work.

Female Telegraphists in Ireland.—In the House of

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Commons, on Thursday, May 10, Mr. Kenny asked the Postmaster-General whether it was a fact that the female telegraph clerks attached to the Dundalk office were required to perform the entire of the telegraph Sunday duty of that office, in addition to the limit of 48 hours per week, as laid down by his late revision; and, if so, whether any compensation had been allowed for this extra duty. Mr. Fawcett said: "In reply to the hon. member I have ascertained that the two female telegraphists employed at the Dundalk office work during the six week days the usual time of 48 hours. In addition to this each of them works two hours on each alternative Sunday. They are entitled to extra pay to the extent of two hours a fortnight, and I have given instructions that the amount due to them shall be paid. The night work is done entirely by the male staff."

Bradford Provisional Order.—At the last meeting of the Bradford (Yorks.) Town Council the town clerk reported that the officers of the Board of Trade had invited him and the parliamentary agent and the electrical engineer of the corporation to a conference on the points connected with the Bradford Provisional Order, on which the board and the corporation differed; that a conference had accordingly been held, resulting in a satisfactory arrangement; that the area within which the corporation are to exercise their powers within two years was limited to Market-street, Bank-street, and Darley-street; that power was given to the corporation from time to time to determine by resolution to what other districts they would extend their operations, without application to the Board of Trade, and that the board had determined to adopt the Bradford order as the model for other Corporation Provisional Orders. A member of the council stated that for this gratifying result they were indebted to their town clerk.

Oil Tanks Fired by Lightning.—The following telegram appeared in the *Standard* of Friday, the 11th inst. It was dated New York, Thursday night (May 10), and stated that: "During a storm to-day (Thursday) the lightning struck and set fire to a wood factory in the midst of a dense tenement-house population adjoining the Belle Vue Hospital in Jersey City. For a short time the excitement was intense, but the amount of damage was small. Another flash did more damage. It struck the Standard Oil Company's works in Jersey City, and a huge iron tank exploded with a violence which shook the earth for a long distance. The flame which immediately rose was seen twenty-four miles off. Ponderous fragments of the tank were thrown a distance of half a mile, and the crowds who assembled on the top of a neighbouring hill a mile away were scorched. The blazing fluid poured in a great stream towards the river, and on its way ignited other tanks. The workmen and firemen ordered to retreat before this sudden foe started upon a fearful race; their hair and clothing were singed, and the six who were most in the rear were overwhelmed. It is feared that other fatalities have occurred. The destruction has involved eighteen tanks of crude oil and two of naphtha, each averaging, perhaps, ten thousand barrels. The works, which covered twenty acres, also contained many thousand barrels of refined oil. The loss is variously estimated at sums all of which approach one million dollars."

A Cable for Sale.—Tokenhouse-yard is to witness a remarkable lot under the hammer on the 22nd inst., and from the fact that it lies electrically inert at the bottom of "the deep blue sea," and may have served the mermaids for a skipping rope, or possibly a crinoline, to say nothing of what uses Father Neptune has found for it, Mr. George Robins, of immortal memory, would have had a subject to his own heart for giving reins to the pleasures of the imagination, were he alive to handle the hammer in connection with such a novel subject of competition. The lot in question is none other than a submarine telegraph cable extending from Para, in Brazil, to Cayenne, in French Guiana, and to Georgetown, in British Guiana. There is something delightfully speculative about this prospect of investment beneath the foaming billows, especially as the Court of Chancery, with a fine regard for fairness, only promise to secure to the purchaser the cable as it now actually exists, while the particulars expressly set forth that it has not been for some time in use. Moreover, with a delicious frankness—for whenever was a house announced to have had its drainage out of order, or smokey chimneys when last occupied?—this mysterious link beneath the ocean wave "is believed to have been defective when last used." Those who assemble at the Mart to see what bold investor in submarine telegraphy will be forthcoming, might, it is certain, wend their way to Tokenhouse-yard for an indefinite period before they again have particulars of sale brought under their notice containing so little in the way of piling on the agony in florid description of possible advantages.—*City Press.*

Electric Lighting in Theatres.—We take the following account of some recent experiments at the Opera House, Vienna, from a Viennese paper. They were carried out in the presence of a large audience, who had been specially invited for the occasion. The installation consisted of 1,236 incandescent lamps fed by two hundred accumulators, the latter being supplied by the Electrical Power Storage Company, of London, and was put up by the Anglo-Austrian Electrical Company. The first scene showed a room in which broad daylight, produced by white lights, gradually turned into night with the aid of the whole of the lights. After this experiment, which went off with surprising steadiness, the audience broke out into loud applause. Great interest was excited by the carrying of a candelabrum across the stage. The light was made to follow the same with a marvellous likeness to nature, and the effect of blowing out first one candle and then the other, and subsequently relighting them, was very highly appreciated, as showing a complete command over the whole or partial illumination of the stage. After further experiments came a trial of costumes. About fifty "supers," male and female, crowded the stage—monks, pages, knights, hussars, priestesses, Egyptians, ballet dancers, &c., in dresses of motley make and hue. The light showed up the costumes perfectly clearly, without the materials losing any of their brightness or gloss. After this trial the scene was changed, and experiments followed with landscape scenes. Bright daylight gradually changed to moonlight, succeeded by sunrise, deepening to morning glow; this lighting began at the cross battens, then flies, battens, and footlights, followed by a thunderstorm, with lightning. All these experiments went off without a hitch, and with the most perfectly equable distribution of light, obtaining the congratulations of all present, including several leading Viennese experts.

Vienna Electrical Exhibition.—We have received from the Science and Art Department a copy of a recent decree of the Austrian Minister for Commerce, having reference to the protection of patented machines, &c., during the course of the exhibition. The conditions laid down are as follow:—1. Applications for certificate of protection to be made as soon as possible by owners of objects or by accredited agents, and to be accompanied by the necessary plans, drawings, and duplicates, together with the authorisation for the agent to act. [These applications and requests

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for more detailed information must be addressed to the Privilegien Department for the Imperial Ministry of Commerce, Vienna.] 2. Before request is considered exhibitors must state whether necessary formalities have been complied with and make certain other declarations. The objects will afterwards be examined and reported on. 3. Certificates will be issued conjointly by the Ministry of Commerce and the Hungarian Minister of Agriculture and will take effect from date of entry to 31st December, 1883. 4. Certificates will be made out in annexed form, and arbitrators will decide disputed points. 5. No complaints of the refusal to grant a certificate will be considered by the Government departments. If the legality of such decision is questioned the matter is to go to the arbitrators. 6. Complaints will not be dealt with by the department, but referred to the arbitrators, and questions of misdescription will be treated in accordance with Rule 4. 7. The certificates of protection issued will be published in the *Austro-Hungarian Gazette*. The decision in contingencies not provided for is vested in the Minister of Commerce.—From information received from Vienna we gather that it is the intention of the organising committee to fix an arc lamp of 20,000 candle-power in the topmost, or lantern-gallery, of the Rotunda, where the exhibition is to be held; the light from this lamp will be deflected by means of reflectors. Another gallery below this is to be wreathed with twenty-eight arc lamps of from 2,000 to 3,000 candle-power, whilst on another and larger gallery yet further below will be placed 112 arc lamps of about 1,000 candle-power each. The ground floor of the building will also be lighted by numerous arc lamps, whilst the transepts, galleries, and courts will be brilliantly illuminated by incandescent lamps. Powerful search lights will be fitted on the outside of the building, the light from which will be thrown on to distant objects, such as notable buildings, &c.

Injuring Telephone Wires in London.—At the Guildhall police-court on Wednesday Theodore Torry, manager at the Globe Telephone Company, and William Goodfellow and James Molyneux, two men working under him, were charged by the United Telephone Company, before Alderman Stone, for wilfully and maliciously injuring their wires. Mr. J. P. Grain appeared for the complainants; and Mr. George Lewis for the Globe Company, to defend the men. Mr. Grain said that he was proceeding under the 27th section of the Malicious Damage to Property Act, by which any person being found guilty was deemed guilty of a misdemeanour, and was liable to imprisonment not exceeding two years, with or without hard labour. The United Telephone Company had a large number of subscribers, and enjoyed a large revenue. That company being successful, the owners of the invention worked by the company started the Globe Company in opposition to them, and hence the conduct of the workmen towards the complainant company. The course they adopted was to tie their wires together with other wire, so that when a current of electricity went through one of them, instead of setting one bell ringing, it would set forty ringing at once. The company, when they got permission to work the patent, made arrangements with the authorities of Weavers' Hall to have two poles placed on the roof of the hall, to which they could convey their wires from their office, and thence to their different customers. One of their lines passed over the Wool Exchange, in Coleman-street, where the Globe Company had offices. They put on the roof of that building, to carry their wires to other points, what was termed a derrick; but the wires of the United Company did not interfere with the wires of the Globe Company; yet, notwithstanding that, they tied up the wires of the United Telephone Company and put them all in confusion.—James Reynolds, 36, Brook-road, Upper Holloway, labourer, said that in the beginning of May he was in the service of the Globe Company. On the 1st of May he was on the top of the Wool Exchange running wires for the Globe, and Molyneux and Goodfellow were there also. Torry was on the roof during the greater part of the time, giving orders, witness believed. Molyneux was his foreman. In consequence of orders received, Molyneux on one occasion tied the wires up with another wire in three places. That was on Wednesday, the 2nd of May, and a current of electricity was then put on and connected from the wires of the United with the battery room of the Globe. That would cause a ringing of the bells of the subscribers, and the men had a laugh about it on the roof, as they knew what the result would be. He also gave evidence as to other acts in which the wires had been tied up. Mr. Lewis cross-examined the witness as to his knowledge with regard to who gave the order for what was done, and who was responsible for it. Upon the adjournment of the inquiry Mr. Lewis complained that Mr. Grain had made statements under instructions which circumstances would not justify. The two companies were in litigation in chancery, and had already spent £30,000 in law costs. He said the case ought not to have been brought before that court, but before the Court of Chancery. The further hearing was then adjourned.

Legal Decision as to Electro-Plating Patents.—The case of the Plating Company (Limited), appellants, and Farquharson and others, respondents, came before the House of Lords recently, and we may conclude that their decision has settled this long contended suit. There were present—The Lord Chancellor, Lord Watson, and Lord Fitzgerald. The appellants appealed against the judgment of the Court of Appeal, which was against them. In giving judgment the Lord Chancellor said:—"I agree with the Court of Appeal in considering that the respondents' solution is, in fact, prepared in a manner substantially different from the method described in the appellants' specification. The bath which the respondents use for the process of deposition is prepared by dissolving in water a crystallised salt, prepared and sold by Mr. William Elmore, whose evidence appears to me to be worthy of credit. The appellants themselves have also, for some time, bought and used the same salts of Mr. Elmore's manufacture, and it is noticeable that they have not gone into any evidence for the purpose of showing that the chemical composition of these salts is identical with that of the salts manufactured in the way described in their specification. The preparation of these salts (used by the respondents), according to Mr. Elmore's evidence, is conducted by an extremely simple process. The electricity in the respondents' process is generated by a dynamo electric machine, and not by a battery, and it appears from the evidence of the appellants' witness, Brooks, that a dynamo electric machine as ordinarily used, though producing a current many times stronger than Smee's or Grove's batteries, is not found to cause ammonia to be evolved from the bath. While the respondents' solution is made from crystallised salts by two perfectly simple operations—the second to be repeated only if the salt is very acid after the first crystallising—the method of preparing the patentees' solution, described in the specification, requires seven distinct operations, of which the first three are apparently the most important—being entirely occupied in the preparation of a dry anhydrous sulphate of nickel without the use of nitric acid—by an elaborate process, requiring the application of regulated heat, in a manner wholly different from that in which the respondents' crystal-

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lised sulphate of nickel is obtained, and the purpose of these successive operations is to eliminate, in that stage, those impurities which by the respondents' method are thrown off into the mother liquor, when the double sulphate crystallises after the two mixed sulphates have been dissolved and boiled. These differences are the more important when it is borne in mind the use, for the electro-deposition of nickel, of the double sulphate of nickel and ammonia was confessedly not new, and that all which the patentee proposed to do was 'to adopt process in the preparation of the solutions,' and to 'observe precautions,' which might obviate the defects in the previous modes of preparing them and get rid of impurities which the previous modes had failed to remove. The result is that there is, in my judgment, no infringement of the patent as limited by the disclaimer. The products of deposition are not patented; nothing is, in fact, patented but the one particular method described in the specification of preparing the solutions of the double sulphates which the appellants or Brooks formerly used, but do not, apparently, now use, and the solution used by the respondents is prepared in a substantially different way. I therefore move your lordships to dismiss this appeal with costs." Lords Watson and Fitzgerald concurred, and the order appealed from was affirmed, and the appeal dismissed with costs.

Electric Lighting in the House of Commons.—On Thursday (May 10), on the House going into Committee of of Supply on the Civil Service Estimates, the following not very creditable discussion arose with reference to the lighting of the dining room by the Edison Company. We borrow our account of the proceedings from the report furnished to a daily contemporary. It appears that the matter was first brought to notice by Mr. Gorst, who complained of the varying brilliancy of the electric light in the reading room of the House, and asked whether any other than the Edison Company had been invited to tender for the lighting, and whether tenders would be invited from other companies before the electric light was used in other parts of the building.—Mr. S. Lefevre explained that, as a proposition had been made to him by the Edison Company to light the dining rooms and library of the House experimentally for a very small sum, he had thought it desirable that members should see what the effect would be. It did not appear to him that electric lighting in its present stage was a proper subject for competition. When arranging for the lighting of the Law Courts he had considered the whole subject, and had come to the conclusion that he could not invite competition. It appeared to him to be the best plan to select the system he thought most likely to answer. He came to the conclusion that the Swan light was best adapted to the Law Courts. Between the Swan and the Edison he saw little difference. As he gave the preference to one in the the case of the Law Courts it appeared to him not unreasonable to try the Edison in that House. Whether it would be ultimately adopted he could not say. He would consult the comfort and wishes of hon. members.—Lord R. Churchill repudiated a suggestion by Mr. Lefevre that he might be interested in the Swan or any other company; but the Swan Company had lit the Law Courts in a manner which had satisfied everybody, and had made almost superhuman exertions to get the lighting in the Law Courts ready for the Royal opening, and they certainly on this account deserved some notice from the First Commissioner of Works. The complaint of the other companies was that without saying a word to any of them the Office of Works concluded an arrangement with this Yankee adventurer, who was shrewdly suspected of having stolen the patent of Mr. Swan himself, and had let him light the House of Commons, which was, without exception, the greatest advertisement they could possibly give to an electric lighting company. It was now known all over the world, wherever there was a parliamentary assembly, that the Edison Company were lighting the House of Commons. Though he was not interested in these companies there were directors of the Edison Company in the House, and the right hon. baronet, the member for the University of London, was the principal director of the Edison Company. Mr. Bouverie, a great supporter of the Whig party, was a member of the Edison Company; and it was, he believed, notorious—and if not a fact it should be easily disproved—that Mr. Preece, the electrician of the Post Office, was a large shareholder in that company. It was important that where electric lighting was the subject of the most tremendous speculation on the Stock Exchange any Government official who thought it right to introduce electric lighting into public buildings should take the utmost care that there should not be the slightest advantage given to one company over another. The Edison Company had already had the trial, which the First Commissioner said they ought to have, at the Post Office. He had no right to give the advantage over an English company to an American adventurer who had obtained a patent by extraordinary and questionable ways, and, he believed, never took out a patent until Mr. Swan disclosed his patent. He hoped before the Government concluded any further arrangements with this most adventurous company the First Commissioner would put everything with respect to the lighting of the House or public buildings up to tender, reserving to himself, of course, the right of ultimate selection.—Mr. S. Lefevre was sorry if he had done the noble lord any injustice, but his speeches on this subject appeared to him to have been directed not from the point of view of the interests of the public and of economy, but in the interests of some rival company to that which had been lighting the House. There was not a word that had been said against the selection of the Edison Company to light the House that was not equally applicable to his selection of the Swan Company at an earlier date to light the Law Courts. The Edison Company laid before him certain reasons, upon which he was satisfied that their system was best adapted to the House at the time. For one thing, they had, and were the only company who had, a noiseless dynamo—(Lord R. Churchill: "No")—and it was a great object that the process of lighting that House should be accomplished without noise. But the difference between the Swan and the Edison systems was so small that on the whole he thought it not unreasonable to give the Edison system a trial. As to its belonging to an American adventurer, that he thought was a very unfair representation. Mr. Edison was one of the most distinguished scientific men of the day, and was beyond all suspicion of the character mentioned by his noble friend. The company formed in England was of a highly respectable character, presided over by Mr. Bouverie, who, the noble lord insinuated, was a political supporter of the Government. When the contract was made no considerations of that sort had any weight with the Office of Works.—Mr. O'Donnell said it was strange that the Swan Company, having done well in the Law Courts, were not allowed to try the House of Commons also.—With reference to Lord R. Churchill's remarks, Mr. Arnold White, the secretary of the London Edison Company, writes in *The Times* of the 14th inst. warmly defending Mr. Edison, and stating that Mr. Preece's name is not on the register of shareholders of the Edison Company.

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DR. NORVIN GREEN.

It will be remembered that in our issue of May 5th we reported the welcome given by the Atlantic cable companies to Dr. Norvin Green, the president of the Western Union Telegraph Company of the United States. The telegraphic system of America is the outcome of private enterprise, and has not yet been nor does it seem likely just at present to be taken under State control. The Western Union Company's system is *the* telegraphic system of America, and hence the president of the company has a somewhat corresponding position there to that of Mr. Fawcett here.

We have great pleasure in giving this week a portrait of the gentleman to whom the welcome we have referred to was extended, and we intend to give in our next issue but one a portrait of Mr. John Pender, M.P., who so ably presided on the occasion.

A brief history of the Western Union Company will be found in that excellent work—a work which, unfortunately, in this country of Cooke and Wheatstone, has no counterpart—"The Telegraph in America; its Founders, Promoters, and Noted Men," by James D. Reid. Like other comprehensive telegraph systems, this great company resulted from the amalgamation of smaller companies, and it is a living proof that telegraphy must ultimately and necessarily be, in any given district, a monopoly. Competition has its uses—and very good uses too—to a point when competition becomes costly, and tends to retard instead of to accelerate telegraphic traffic. We may quote, in connection with this statement, the last paragraph of chap. 35 and the first paragraph in chap. 36 of Reid's book, which are as follow:—

Dr. NORVIN GREEN.

"Among other incidents which prefaced the morning, which, after a time, came flushed with the rosy light of a brighter day, was one significant enough to remember. One stormy night Wade and Stager met by accident at an eating counter in Selby, Ohio. Neither of them was in the condition of ordering a square meal. Hunger drew them together and made them communicative. Wade acknowledged over his pork and beans that he was making nothing, and told Stager to stop whistling and confess. Stager thus appealed to rested for a moment from his corn beef hash and acknowledged that the balances were on the wrong side. This led to a comparison of notes, and to a pretty clear evidence that the business was enough for one but starvation for two. Duplicate and triplicate rents and double force were eating up the entire income. It became a question with Wade whether to join the O'Reilly or the printing lines. It resulted in Wade's going to Rochester, a union of interests, an issue of 100,000dols. of bonds at 70 for a fresh effort, a general closing of all duplicate expenses, and success."

"One of the immediate results of the purchase lease and union of all the various interests, narrated in the preceding chapter, and their incorporation into the Western Union Telegraph Company, was the stoppage of numerous rents and the giving up of numerous choice corner offices, which had been hungrily seized upon at large prices in the contest for business. In this single direction an annual economy of over seventy thousand dollars was at once secured. It was soon felt, also, in a marked enlargement of business, a promptness it had never before reached. This was soon felt by those who most needed and relied upon its employment. Where answers to despatches of one day had been received, as a general rule, on the day following, these now came on the same day, sometimes in quick and gratifying response to the original message. Some messages were actually refused because the quickness of the response seemed incredible. It was like fresh blood to a system which, up to this time, had, in a great degree, failed to meet the expectations of the public. The well known card over the locked door of the office, 'gone to mend a break,' was no longer seen. Every thing had changed. The wires were steady, and full of business."

The views we have here illustrated are, we believe, quite in accordance with those pursued by the subject of our sketch. The following personal observations relating to Dr. Norvin Green are taken from the *Operator* of October 21, 1882:—

"Dr. Norvin Green was born in Kentucky, in 1818. He graduated in the Medical Department of the University of Louisville in 1840. Afterwards he served several terms in the Kentucky Legislature, with distinction, and in 1853 was appointed commissioner in charge of building a new custom house and post office in Louisville. In 1854 he became interested in telegraphy, and was soon made president of the South Western Telegraph Company. He was at that time a noted and popular man. Uniting good judgment and good sense with a decided ability as a stump speaker, and even ready to take a prominent part in the broad humours of a Kentucky barbecue, he was as much a popular favourite as he was a man held in high esteem by business men for his sagacity, firmness, and practical talent.

"After a career of brilliant success, under Dr. Green's vigorous and liberal administration, the South Western Telegraph Company fell into line with the general movement for consolidation, and was merged in the American Telegraph Company, which became in turn a constituent part of the Western Union. In recognition of the ability of Dr. Green he was thereupon made a vice-president of the Western Union, which position he filled, quietly and unostentatiously, but with extraordinary efficiency, until the death of President William Orton, whose successor he became by inevitable selection.

"The office of president of the Western Union Company requires a rare combination of qualifications. It has to deal with complicated legal and political problems, and is liable

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to encounter difficulties from State legislation. The president must, therefore, not only have a thorough practical knowledge of the telegraphic system of the country, but he must have experience in public life and a knowledge of public men. It would be difficult to find a man possessed of these qualifications in the same degree as is Dr. Green. For more than a quarter of a century identified with telegraph management in responsible positions, he was long ago recognised as a man of statesmanlike breadth and attainment, and in 1869 was one of three candidates before the Kentucky Legislature for the United States Senate, on which occasion he was only defeated by a blunder of one of the caucus tellers, who, by mistake, counted a vote given for him as for a third candidate."

ON ELECTRIC STREET MAINS.

BY GISBERT KAPP.

There are two principal ways in which a district can be served with a direct supply of electricity from a central station. We can either lay down a heavy main line right through the middle of the district, and connect to it small branch leads which otherwise are not connected amongst themselves, or we can dispense with a heavy main line, and in its stead provide plenty of connections between all the different branch leads and between the station and some of the nearest branch leads.

In the first case, a positive lead is brought from the station to the far end of the main line, and from there brought back to that branch which is nearest the station. All the branches are connected to this returning positive lead and to a single negative lead, which goes from the station to the far end of the main line. Three leads are thus necessary, and a complication is thereby introduced, which at first sight may seem useless; but it is sometimes claimed for this system that when properly varying the potential at the station, in accordance with the demand for current in the district, all the branch leads can be kept at a fixed potential, no matter how fluctuating may be the consumption of current in different places. This system might aptly be called the *line of centres system*, for the main line is in reality nothing else than a succession of feeding centres for the branches.

The other system, where all the positive leads are connected among themselves in as many ways as possible, and the negative leads are similarly connected, might be called the *network system*.

In this arrangement the current is not made to flow along one definite route only, but, finding alternate ways open, it will naturally split up between the meshes of the network in such manner that the sum total of energy lost through resistance in the different circuits is a minimum. This, of course, is a very desirable result, but the drawback of the system is that the difference of potential near the station will be greater than that existing at distant points.

Considering the large amount of capital which must be laid down in mains if public and private lighting is to come into use, the question of selecting the best possible system is of great importance.

Whether one or the other, or a combination of both systems, should be employed must always depend upon the particular circumstances of the case, and, generally speaking, the necessary ramifications of a set of street mains are so complicated that a correct choice at first sight is not an easy matter.

If we reduce the two systems to their possible simplest forms, we find for the line of centres system an arrangement as per Fig. 1 or Fig. 2, and for the network system an arrangement as per Fig. 3. The arrangement shown in Fig. 1 has been described above; Fig. 2 is a modification of the same, the connections being made between the returning positive and outgoing negative lead on the one hand, and the returning negative and outgoing positive lead on the other hand. To distinguish the two arrangements, we will call Fig. 1 the single, and Fig. 2 the double line of centres system.

As regards Fig. 3, it might be objected that it does not in the least look like a network. Yet it is correct to classify it as such, for the best possible network is evidently that in which each circuit carries exactly the necessary amount of current for the lamps or motors upon it, so that no part of the current has to take the alternate and longer route through the connecting branches between the different circuits. Fig. 3 can be taken as representing one of the circuits of a well designed network.

On page 162 of Vol. XII. of the *Journal* of the Society of Telegraph Engineers and of Electricians, Messrs. Ayrton

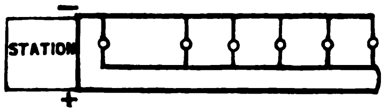

FIG. 1.

and Perry have shown that even in such a simple case as that when only two centres are being served, it is not possible to maintain both at a fixed standard pressure if the demand for current in each branch varies. With more than two centres the calculation becomes too complicated, and the results are obtained in a form too involved to be readily analysed; but it is clear that what is impossible in the case of two centres must be impossible in the case of three, four, or more centres. To prove this, we have only to consider that by singling out any two neighbouring centres, and allowing, for sake of argument, any amount of variation in all the other centres, we bring the case back to the simplest form, for which it has already been proved that, no matter how we may vary the pressure at the terminals of the line, it is impossible to keep the pressures at the two centres exactly at the standard value. By a similar reasoning we can prove this for any other pair in our line of centres, and thus it follows that the great ad-

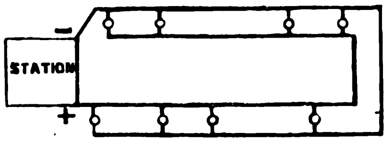

FIG. 2.

vantage claimed for this system of equalising the pressure all along the main line is purely imaginary.

Let c_1 and c_2 be the currents taken from the line of centres at A and B in Fig. 4., p_1 and p_2 the corresponding pressures (or differences of potential) in these points, E the difference at potential between the terminals P_1 and P_2 of the line, and ρ the resistance of a unit length of conductor, then by applications of Ohm's law we find

$$p_1 = E - (c_1 + c_2) D \rho + c_2 d \rho,$$
$$p_2 = E - (c_1 + c_2) D \rho + c_1 d \rho,$$

which equations are the same in substance as those given in the above mentioned journal.

If the two centres A and B were supplied at the same pressure, the difference between p_1 and p_2 must be zero, and this can only take place if

$$c_1 = c_2.$$

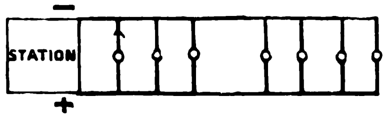

FIG. 3.

In all other cases we have

$$p_1 - p_2 = (c_2 - c_1) d \rho,$$

and therefore the difference between the pressures in A and B cannot remain constant if the currents vary. By varying the difference of potential between P_1 and P_2 (or between P_1 and $P_2{}^1$, which comes to the same thing), it is possible to keep the pressure at one of the two centres exactly at the proper standard, but then the pressure at the other centre must be wrong. It is impossible to make it right for both

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at the same time, and as with a greater number of centres this difficulty is not removed, but probably somewhat increased, it follows that the line of centre system does not equalise the pressure.

It might be, however, objected that, by assuming only a few centres which necessarily are wide apart, we do not get a correct representation of the actual supply which will in most cases take place at a great number of points all more or less evenly distributed. Even in that case the pressure is not equalised. To put the most favourable conditions possible, we will assume that all along the line a constant quantity of current per unit length of main is taken. Let C be the total current used in the district, l the length of the line of centres, and x the distance of A from the station (Fig. 5), then the current passing by A in the positive lead is $C\left(\frac{l-x}{l}\right)$, that passing by A in the negative lead is $C\frac{x}{l}$.

Let p_1 be the absolute potential in the positive lead at the distance x from the station, and p_2 the absolute potential in the negative lead at the same distance; then, if we call the potentials at the distance $x + dx$ respectively $p_1 + dp_1$ and $p_2 + dp_2$, we find,

$$dp_1 = -C\left(\frac{l-x}{l}\right)\rho\, dx$$

$$dp_2 = -C\left(\frac{x}{l}\right)\rho\, dx,$$

ρ being now, as before, the resistance of a unit length of conductor.

By integration we find

$$p_1 = -C\rho x + \tfrac{1}{2}\frac{C\rho x^2}{l} + Q_1,$$

$$p_2 = -\tfrac{1}{2}\frac{C\rho x^2}{l} + Q_2.$$

Q_1 and Q_2 being constants which can be determined by noting that for $x = 0$ we have $p_1 = P_1$, and for $x = l$ we have $p_2 = P_2$,

$$p_1 = P_1 - \tfrac{1}{2}C\rho\left(\frac{2xl - x^2}{l}\right),$$

$$p_2 = P_2 + \tfrac{1}{2}C\rho\left(\frac{l^2 - x^2}{l}\right).$$

The difference of potential at the point A, or, as we have called it, the pressure in A, is, therefore,

$$p = p_1 - p_2,$$

$$p = P_1 - P_2 - \tfrac{1}{2}\frac{C\rho}{l}(2xl - 2x^2 + l^2).$$

We obtain the pressure at either terminal of the line by putting

$$x = 0 \text{ or } x = l,$$

$$p = P_1 - P_2 - \tfrac{1}{2}C\rho l.$$

If this be taken as a standard, the pressure at any distance x can be given with reference to it. It is

$$p = p_t - \frac{C\rho x}{l}(l - x).$$

By forming $\frac{dp}{dx} = 0$ we find that the point of greatest variation occurs for $x = \frac{1}{2}l$, that is, in the middle of the line. The pressure in this point is

$$p_m = p - \tfrac{1}{4}C\rho l,$$

and therefore the greatest possible variation in pressure is

$$\tfrac{1}{4}C\rho l.$$

It will be interesting to compare with this the greatest possible variation we would have to expect had we employed the same amount of copper in the network system. The arrangement in this case would be as in Fig. 6, where each of the branches carries half the current and is half the length as before.

In a former article (*see Electrician*, Vol. X., p. 81) it has been shown that the loss of pressure between the first and last parallel is equal to one-half of the electromotive force which would be necessary to drive the total current right round the the main leads if their far ends were joined up.

In this case the total current is $\frac{1}{2}$ C, the length of leads joined up is l, and hence the loss would be $\frac{1}{2}\cdot\frac{1}{2}C\rho l$. That is precisely the same as in the case of the line of centres arranged as in Fig. 5.

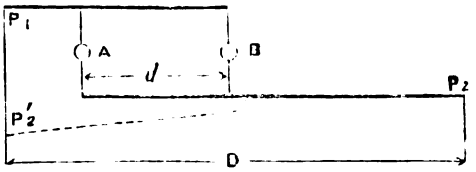

Fig. 4.

It will thus be seen that with regard to variation in pressure the double line of centres system offers no advantage whatever over the network system. It will be interesting to investigate whether the single line of centres system offers some such advantage. We must again assume that the same amount of copper is used, but now subdivided into three cables, instead of into four (Fig. 7). By virtue of this arrangement the resistance of the conductor per unit length is only $\frac{3}{4}$ of its former value, and the length of the line is one-half of what it was before. By making these corrections in the above formula for p, we find

$$p = P_1 - P_2 - \tfrac{3}{4}\frac{C\rho}{l}\left(xl - 2x^2 + \frac{l^2}{4}\right).$$

The greatest pressure occurs at the terminals where $x = 0$ and $x = \frac{1}{2}l$; it is

$$p_t = P_1 - P_2 - \tfrac{3}{4}\frac{C\rho l}{4}.$$

The least pressure will be found in the middle of the line; $x = \frac{1}{4}l$ gives

$$p_m = P_1 - P_2 - \tfrac{3}{4}\frac{3C\rho l}{8}.$$

Hence the greatest possible variation in pressure is

$$\tfrac{3}{4}\frac{C\rho l}{8}.$$

That is only $\frac{3}{8}$ of the variation we found in the double line of centres system.

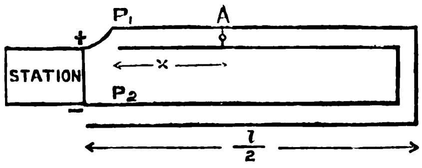

Fig. 5.

Next to equalising the pressure, the question as to the energy expended in heating the mains is of greatest interest. The current is sold to the customers at the pressure p, but it has to be put into the mains at the higher pressure E; hence, if we neglect leakage, $y = \frac{p}{E}$ is the efficiency of distribution.

If we compare the three systems with regard to the maximum loss of pressure, we find it for the network

$$E - p_m = \tfrac{1}{4}C\rho l,$$

for the double line of centres

$$E - p_m = \tfrac{3}{4}C\rho l,$$

and for the single line of centres

$$E - p_m = \tfrac{3}{4}\cdot\tfrac{7}{8}C\rho l.$$

That is to say, in the double line of centres system we waste three times, and in the single line of centres system we waste 2·63 times as much energy as in the network system. An example will be interesting. Assume we have to supply current on both sides of a street 500 yards long, the average demand for electricity being, say, one ampere per yard. In all we shall therefore have 1,000 amperes of current. To

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carry this current safely we take a conductor whose resistance is $\rho = 0{\cdot}00004$ per yard (this is approximately the resistance of 19 strand ·205). We find $c \rho l = 40$, which, inserted into above formulæ, gives for the greatest variation of pressure along the line and for the horse-power lost in heating the mains the following figures:—

	Volts.	Horse-power.
Network system	10	13·4
Double lines of centre system	10	40·3
Single lines of centre system	3·75	35·3

They refer to the time when the full supply is on; at any other time the variation as well as the power wasted are less than given above. Now as to working our installation. It will be clear that in all the three systems some variation of pressure at the station in accordance with the varying demand for current would tend to let each individual customer have his supply at a more even pressure than in the case where absolutely no variation in the pressure at the station was made. For instance, in the case of the network, if the

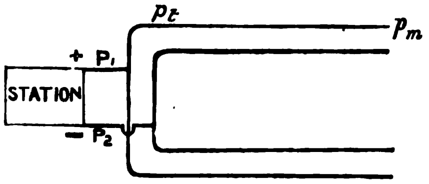

Fig. 6.

standard pressure were fixed at 150 volts, we would work up to 155 volts when sending out the maximum current of 1,000 amperes during certain hours of the evening; and during the daytime, if sending out only very little current, we would maintain only 150 volts. In this manner the customer nearest the station will receive the supply at 155 volts in the evening, and at 150 volts during the day, and the customer farthest from the station would receive 145 volts during the evening, and 150 volts during the day, whilst the pressure about the middle of the circuit would hardly vary at all. In providing the nearest customer with motors or lamps which require 152·5 volts, and the farthest customer with such requiring 147·5 volts, we should always be within $2\frac{1}{2}$ volts of our standard pressure; that is as near to it as can reasonably be demanded. In a similar manner we would arrange matters if either of the two other systems were adopted, only that in this case the variation at the stations would have to be far greater than five volts. As this is a most important point when deciding upon the merits of the different systems, a comparison of the figures in the following table will be use-

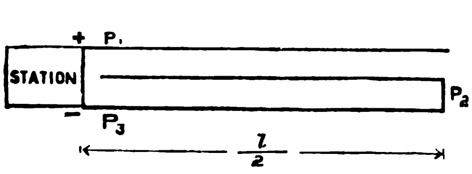

Fig. 7.

ful. N means network, D double, and S single line of centres system. The efficiency of distribution is taken as the ratio between the mean standard pressure of 150 volts and the maximum pressure required to be kept up at the station when the full supply is on:—

1,000 amperes, 500 yards, 150 volts.	N.	D.	S.
Minimum pressure at station ...	150	150	150
Maximum " " ...	155	175	170
Lowest standard of pressure ...	147·50	147·50	149·06
Highest " " ...	152·50	152·50	150·94
Greatest variation on the same premises	±2·50	±2·50	±0·94
Efficiency of distribution	96·8 %	85·8 %	88·2 %

This table is very instructive. In the first place it shows what an enormous price we have to pay for securing the imaginary advantage of even pressure in the double line of centres system. Twenty volts and 1,000 amperes is 26·6 horse-power absolutely wasted, without deriving the slightest benefit if compared with the network system. In the second place the table teaches us that, as regards evenness of pressure, the single line of centres system is certainly superior to the network system, but at a large cost of efficiency. We waste 20 horse-power in order to reduce the fluctuations of pressure by 1·56 volt, and it might well be asked whether so slight an advantage is worth this price.

There are, however, two strong practical reasons why, if possible, the line of centres system should be avoided. The one is that not only does it require that the pressure at the station should be varied between wide limits (in this case by 20 volts), but it also requires that at one and the same time there should be kept up at the station as many different pressures as there are lines of centres radiating from that station. It needs only a moment's consideration to show that this must considerably increase the amount of spare machinery, and introduce most objectionable complications into the service. The other and, if possible, still more important reason against the line of centres system is its inability of extension. It will readily be seen that two stations cannot possibly charge into the same line of centres, whilst with the network system this is quite feasible. Thus, any extension of the supply of electricity beyond the limits of the original area can easily be made if the mains form a complete network. New stations, charging into this common network, will have to be established, and by thus multiplying the generating points, any failure of one of these will not result in an interruption of supply in that part of the district, which would of necessity be the case were the district served on the line of centres system. Another advantage of the network system must not be lost sight of. It is this, that mains can be laid, tested, taken up, and repaired or replaced while the current is on.

ELEMENTARY ELECTRICITY.—IX.

(CONTINUED FROM P. 464, VOL. X.)

It has already been shown that the capacity of an isolated sphere is numerically equal to its radius. Henry Cavendish proved that the capacities of spheres are proportional to their linear dimensions, but having no definite unit of potential he had no reason for selecting the radius rather than the diameter of a sphere as the measure of its capacity, and, choosing the latter, he spoke of so many inches of electricity, by which he meant the quantity of electricity which would be imparted to a sphere of that number of inches in diameter when charged to a definite potential, as, for instance, that which could be obtained from his electric machine.

Having constructed a metal sphere about a foot (12·1in.) in diameter Cavendish proceeded to determine the capacities of other conductors by comparison with his sphere. In making these comparisons he employed a "trial plate" consisting of two pieces of tin plate which could be made to slide over one another, and thus the capacity of the trial plate could be varied. To compare the capacities of two bodies, A and B, he charged one of them, A, positively, and the trial plate negatively, but to the same numerical potential, and adjusted the capacity of the trial plate so that, on connecting it with the body A, the charges exactly neutralised each other. He then repeated the experiment with the body B, and compared the dimensions of the trial plate in the two cases. He determined (not quite accurately) the dimensions of a square equivalent in capacity to the trial plate, for different positions of the trial plate, and knowing that the capacities of similar figures are proportional to their linear dimensions (this he proved experimentally), he had all the data requisite for the comparisons of the capacities of A and B. With this apparatus Cavendish tested the capacities of plates of different materials and different thicknesses, and, making a rough correction for the thickness, found that the capacity was independent of the material. In

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trying gold leaf, charcoal powder, gum arabic, tinfoil, &c., he spread the material on glass plates.

In comparing the capacities of bodies of different forms, Cavendish arrived at the following results:—

	Capacity.
A globe 12·1in. in diameter	1·000
A tin circle 18·5in. in diameter	·992
A tin plate 15·5in. square	·957
An oblong tin plate 17·9in. by 13·4in.	·965
A brass wire 72in. long and ·185in. thick	·937
A tin cylinder 54·2in. long and ·73in. diameter	·951
A tin cylinder 35·9in. long and 2·53in. diameter	·999

In comparing the capacities of coated panes, *i.e.*, of accumulators consisting of a plate of glass or other dielectric coated on each side by a conductor, Cavendish employed a trial plate, consisting of a sheet of glass, having its lower side entirely covered with tinfoil, but its upper surface only partially covered. Plates of brass were provided which could be made to slide over the tinfoil on the upper surface, and cover any desired portion of the plate. It was in dealing with this apparatus that Cavendish found difficulties arising from the creeping of the electricity from the edges of the metal over the surface of the glass, and was obliged to introduce a correction based on the assumption that for a particular kind of glass the creeping of the electricity produced the same effect as the enlargement of the armature by a definite amount in every direction. Cavendish concluded that with glass plates, ·2in. in thickness, the electricity spreads ·07in. all round the metal coating instantaneously, and that over this space the electricity has the same density as on the armature. This he determined by using different armatures having the same areas but some having much greater perimeters than others, and comparing their capacities. On rapidly charging and discharging such a coated pane, a beautiful luminous corona appears around the edge of the armature. This is well seen in the Leyden jars attached to the conductors of a Voss machine when the machine is giving spark discharge through three or four inches of air.

Cavendish provided himself with a set of ten coated panes, three having, according to computation, equal capacities, which we may denote by *c*; the next three had each a capacity of 3 *c*, the next three of $3^2 c$ or 9 *c*, and the last plate had a capacity of $3^3 c$, or 27 *c*, making altogether a capacity of 66 *c*. He first proved that the capacities of these plates were not sensibly affected by being placed near each other. This agrees with our explanation of the action of the Leyden jar. The slight disagreement between their computed and their actual capacities Cavendish explained by the spreading of the electricity above described.

By constructing small coated panes having the same capacities as the globe, of 12·1in. diameter, Cavendish determined the capacities of each of the coated panes in terms of that of the globe. In comparing his results with theory he took into account the fact that the proximity of the walls, ceiling, &c., of the room increased the capacity of the sphere, and he treated the room as itself a sphere 16ft. in diameter.

Employing two metal plates separated by little pillars of sealing wax, Cavendish measured the capacity of an air condenser.

The results of the measurements of the coated glass panes showed that their capacities were about eight times that which Cavendish's theory indicated, on the assumption that the electricity did not soak into the glass. By grinding down plates of glass so as to leave only the central portions Cavendish found that the outer layers were as good insulators as the inner layers; and the conclusion at which he arrived was that the glass consisted of portions, occupying in all about seven-eighths of its volume, which were comparatively good conductors, so that as far as action *across* the glass plate was concerned it behaved as though it consisted of alternate very thin layers of air and metal, the total thickness of the metal being about seven times that of the air. The result of Cavendish's measurements would be expressed in Faraday's language by saying that the specific inductive capacity of Cavendish's glass was about 8.

Cavendish afterwards observed that the charge of a glass condenser depends very much on the time during which it is charging, and that it "contained more electricity when it continued charged a good while than when charged and discharged immediately." This phenomenon of electric absorption occasions great discrepancies between measurements of specific inductive capacity, especially of glass, when the period of charging is in one case a second or two, and in the other very short, such as one ten-thousandth of a second, and it appears that a great deal of "absorption" takes place in a very small fraction of a second.

Cavendish determined the specific inductive capacities of substances other than glass, such as shellac, beeswax, and a mixture of beeswax and resin. Of these shellac had the greatest specific inductive capacity, but it was not much more than half that of glass.

After Cavendish the next worker in this subject was Faraday, who rediscovered specific inductive capacity, as previously stated. In 1871 Messrs. Gibson and Barclay published a paper on the specific inductive capacity of paraffin, a great impetus having been given to experimental work in this department by the publication of Clerk Maxwell's electromagnetic theory of light, for, according to this theory, the refractive index of a non-magnetic medium (and the magnetic permeability of nearly all transparent media is sensibly the same as that of air) ought to be equal to the square root of its specific inductive capacity, and this equality appears to afford the most ready means of testing the validity of the theory. Messrs. Gibson and Barclay's results, obtained with separate paraffin condensers, gave for the specific inductive capacity of paraffin the numbers 1·975 and 1·977 respectively.

Boltzmann employed a condenser, consisting of two metal plates, the distance between which could be varied, the plates moving so as to remain parallel to one another. Between these metal plates a thick plate of the dielectric to be tested could be introduced. The capacity of the condenser was compared with that of a pair of quadrants of the electrometer, which served to make the measurements, first, when there was only air between the plates of the condenser; and, secondly, when the plate of the dielectric was introduced. The comparison was made by noting the deflection of the electrometer when it was connected directly to the charging battery, and then, having discharged the electrometer, its deflection was noticed when the condenser was first charged from the battery, then insulated, and then connected with the electrometer. As these connections could be made and broken in rapid succession, there was not much time for absorption. If the deflection of the electrometer when connected with the battery was 100 and when connected with the condenser 90, it is clear that the charging of the quadrants of the electrometer reduced the potential of the condenser by 10 per cent., and the capacity of the condenser must, therefore, have been nine times that of the quadrants.

When a conductor is introduced into an electric field it suffers electric displacement, and one side of the body becomes positively charged and the other negatively charged. Such a conductor, with its induced surface electrification, will have a tendency to move towards that part of the electric field where the electric force is greatest.

If, instead of a conductor, a non-conducting body whose specific inductive capacity is greater than that of the electric field be employed, it will behave as though there were a surface electrification induced upon it similar to that upon the conductor, but less in amount, its amount increasing with the specific inductive capacity of its substance. Hence a non-conducting body placed in an electric field will, like a conductor, tend to move to the strongest part of the field, and will be attracted by any strongly electrified conductor, the amount of the attraction depending on the specific inductive capacity of the body.

As an example of the similarity in behaviour of a conductor and a dielectric of great specific inductive capacity we may consider the following:—Two plates, A and B, of an air condenser are placed an inch apart, A is charged positively and B connected to the earth. An insulated plate of metal half an inch thick is then introduced between the plates so as not to touch them. The side of this plate near to A will receive a negative charge and the other side an equal positive charge, while the potential of A will be

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diminished, the capacity of the condenser being increased, as if the plates A and B had been brought up within half an inch of each other. The metal plate, in fact, is equivalent to a plate of air of no sensible thickness. A metal behaves as though it had an infinite specific inductive capacity.

Now, suppose the plate of metal replaced by a glass plate of the same thickness. The plate will behave as though the side near to A were electrified negatively, and that near to B electrified positively, but these apparent charges will be less than the actual surface electrification of the metal plate. The result is that the potential of A will be reduced, but not to the same extent as when the metal plate was employed, and the capacity of the condenser will be increased by an amount depending on the specific inductive capacity of the glass.

If a little glass ball be brought near to a positively charged conductor, it will behave as though it had a negative charge on the portion of its surface near the conductor, and an equal positive charge on the part which is more remote. Hence the sphere will be attracted by the charged conductor, the amount of attraction depending on its specific inductive capacity. Boltzmann compared the attractions exerted by a charged metal sphere upon an insulated and uncharged ball of metal, and upon an equal ball of resin, ebonite, sulphur, &c., and hence calculated the specific inductive capacity of the sulphur or other material. To diminish the errors due to absorption or imperfect insulation, the charge of the attracting sphere was reversed by means of a tuning fork 180 times in a second.

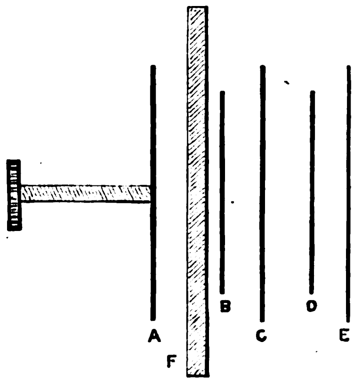
In experimenting with a sphere of crystalline sulphur Boltzmann found that its specific inductive capacities (like its refractive indices) were different for different directions in the crystal. The values of the specific inductive capacities when the electric stress acted along the principal axis of elasticity were 4·773, 3·970, and 3·811 respectively.

Dr. Hopkinson determined the specific inductive capacity, or electrostatic capacity, of different specimens of glass by means of a quadrant electrometer and the sliding condenser used by Gibson and Barclay. This sliding condenser took the place of Cavendish's trial plates. Its capacity could be varied at will by causing a cylindrical conductor to slide in or out of a cylindrical tube. The whole capacity of the sliding condenser could not be determined, but the increase or decrease in the capacity due to a measured displacement of the tube could be readily calculated. The glass whose specific inductive capacity was to be determined was placed between the plates of a very carefully constructed air condenser. The sliding condenser and the air condenser were charged, the one positively and the other negatively, but to (numerically) equal potentials by means of a battery. The battery having been removed, the condensers were connected together, and then both connected with an electrometer. The capacity of the sliding condenser was changed till, on repeating the experiment, the electrometer remained unaffected. When this was the case the capacity of the air condenser and the sliding condenser were equal. On introducing a plate of glass between the parallel plates of the air condenser its capacity was increased, but by means of a screw, the plate which was connected to earth was withdrawn from the receiving plate until the capacity of the condenser, with the glass plate inserted, was equal to that of the sliding condenser, and therefore to that which the air condenser originally possessed. By observing the distance through which the plate had to be moved, the thickness of the plate of air which was equal in its dielectric action to the plate of glass could be determined, and hence the specific inductive capacity of the glass was found. The specific inductive capacities of different specimens of optical glass varied from 6·57 for very light flint to 10·1 for double extra dense flint of specific gravity 4·5.

The principle of this and the method next to be described will be understood from the following:—

The capacity of an air condenser in which the distance between the plates is very small compared with their diameters, so that the excessive amount of electrification accumulated near the edges of the plates may be neglected, in comparison with the whole charge, is inversely proportional to the distance between the plates. Hence, if the distance be reduced to one-half, the capacity will be doubled, and so on. Suppose a plate of paraffin introduced between the plates of the condenser produces the same increase of capacity as would be produced by reducing the distance between the plates by half the thickness of the paraffin. Then it is clear that a plate of paraffin acts like a plate of air of half its thickness, and a condenser having paraffin for its dielectric would have double the capacity of a condenser otherwise equal, but having air for its dielectric. Hence the specific inductive capacity of paraffin must be 2. If, on inserting the paraffin plate, the distance between the condenser plates were increased by half the thickness of the paraffin plate, the capacity would be the same as before the introduction of the paraffin. If a glass plate is employed to keep the capacity unchanged, and the distance between the metal plates has to be increased by seven-eighths of the thickness of the glass, it follows that the glass plate is equivalent to a plate of air of one-eighth its thickness, and the specific inductive capacity of glass is 8.

The specific inductive capacities of several dielectrics were measured by Mr. J. E. H. Gordon by means of the electrostatic induction balance, and the results, together with an account of the experiments, were published in the *Phil. Trans.* for 1879. The balance consisted of fine metal plates, A, B, C, D, E, placed parallel to each other and at equal distances, except in the case of the plate A, which was movable. The plates B and D were connected to the quadrants of an electrometer, which served to determine if there were any difference of potential between them; C was connected with



the needle of the electrometer, and the Leyden jar to which the needle is generally connected was removed. The plates A and E were connected together. The plate C was connected with one pole of an induction coil, and A and B were connected with the other pole, while by means of a high speed brake the primary circuit was made and broken, so that the electrification of the plates A and E and of the plate C with the electrometer needle were reversed 12,000 times in a second. If everything in the balance were symmetrical, the plates B and D would be affected in exactly the same manner, and the needle of the electrometer would remain at rest; but if the induction of A upon B were greater than that of E upon D, the induction of C upon B and D being supposed to be the same, then, when A had a positive charge, the quadrants connected with B would have a higher potential than those connected with D, and the negatively electrified needle would turn towards the quadrants connected with B. But as soon as the electrification of A and E was reversed so as to be negative the quadrants connected with B would be at a lower potential than those connected with D. But the same action which reversed the electrification of A and E also reversed that of C, and with it the electrification of the needle, which, therefore, became positively electrified, and turned towards the quadrant connected with B as before. Thus the reversal of the electrification of the needle, a contrivance due to Clerk Maxwell, enabled the electrifications of all the plates to be reversed many thousands of times in a second, while the electrometer behaved in the same way as if the charges had remained unchanged.

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THE ELECTRICIAN.

TO CORRESPONDENTS.

All letters intended for insertion in The Electrician, *or containing questions, must be accompanied by the name and address of the writer, not necessarily for publication, but as a proof of good faith. No notice whatever will be taken of anonymous communications.*

All communications to be addressed to 396, *Strand, London, W.C.*

We cannot undertake to return drawings or manuscripts, and must, therefore, request Correspondents to keep copies.

ANSWERS TO CORRESPONDENTS.

J. D., Cork.—*Your letter has been handed to us for comment, and we have elsewhere referred to your questions concerning telephony. With regard to obtaining information, you might arrange to do so at the School of Telegraphy, &c.,* 12, *Princes-street, Regent-street, W., or in the Laboratory, King's College, Strand, W.C.*

W. E. Kauke, Byron (Ohio).—*We will make further inquiries, and write to you.*

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ROCKS AHEAD.

No doubt the choice of title for the heading of a leading article is infinite, but when the title is new it is often inappropriate; hence we may be allowed to use one which has done good service before. In commencing our eleventh volume we feel that youth is merging into maturity, that with age our words gather force, the more so seeing that we have tried, in matters electrical, to be faithful guardians of public interests. We have heretofore cautioned the public when caution we felt was needed, and we have at other times attempted to inspire confidence when the outlook was particularly gloomy. In all our writings we have consistently endeavoured to avoid personalities, and to confine our remarks to questions of principle. It has been our misfortune to have to condemn certain electrical applications, but such condemnation was founded upon the knowledge that the laws of electricity and magnetism were in antagonism to those believed in by the sanguine inventor or promoter. The greatest difficulty a responsible scientific writer has to contend against is that of overcoming or combating the prejudices of inventors, and yet the majority of patented inventions are useless and valueless. A man should have faith in himself or his progress is stopped. The difficulty of conviction to a mistake is that most men—especially inventors—have an inherent tendency to believe in their own infallibility and in everybody else's fallibility. There exist at least two other classes of men who thoroughly believe in their own infallibility, and also that mankind as a rule may be reckoned as utterly stupid. These classes are promoters of public companies and those who pin their faith on pure speculation. The combination of patentees, promoters, and speculators forms a triumvirate whose concerted action has not only served to hamper the ship of electrical progress, but has managed to endanger its course by strewing "rocks ahead." If we take as a text the electric light companies which have sprung up like mushrooms by such concerted action during the last two or three years, what do we see? A time of excitement and reckless speculation, a time of depression and ruination, followed by the final act of passing through the court. Commercial enterprise is for a longer or shorter period brought almost to a standstill; real investors lose all confidence in such securities; capital is diverted elsewhere; progress is thus retarded, and the innocent suffer. There is absolutely no means of successfully fighting this concerted action while the daily press lends itself ignorantly or otherwise to pre-arranged plans, and we have, therefore, to witness periodically a recurrence of speculative excitement. Such a period we passed through last year, and now witness the depression, to be followed by the final act. Interested parties are doing all they can to stave off the evil day, but the result is inevitable. We had before us the balance-sheet of one of these concerns but recently, and were utterly amazed to find the company showing a profit and declaring a dividend, when a large portion of its assets consisted of shares in branch companies. The quotations of these shares are slightly higher—we suppose because of the dividend—but if we contemplate the future, and ask to know what work such companies are likely to do, the answer will not be very satisfactory. Before electric light work enters upon a safe footing these bubble companies must go—their promoters never meant real work—they intended to reap a harvest from the confiding public, and have done so to an enormous extent. As soon, however, as the public began to realise the position, their contributions ceased, and the operators, unable or unwilling to prey one upon another, saw the inflated quotations gradually shrinking towards the normal value of the shares, viz., nothing.

Let us consider another phase of electrical work, that of telephony. There is nothing more certain, and we have said this again and again, than that the Telegraph Department must sooner or later appropriate the telephonic system. Promoters of telephonic communication know this, and think, therefore, that excessive watering, and the extension of interests, means simply an increase in the amount to be ultimately paid by the taxpayer. Telephony is in its infancy, yet it seems pretty certain that all local transactions will be carried on by its aid, and that the Telegraph Department will loose a considerable portion of its income by the loss of the local messages. This loss may perhaps be replaced by the royalty paid by the companies, and at first sight the result of the extension of telephony might seem to be the anomalous one of the Government receiving a large amount in subsidies and doing no work. A little consideration will show that the value of telephony depends largely upon the numbers connected by the system. A merchant will not have two rival instruments in his place, and, further, the public will not tolerate the infinite increase of overhead wires. The larger American towns are already abolishing overhead wires, as we had practically done with regard to telegraphic wires, and must do with regard to telephonic wires as well. Then we have attempts to float companies to establish long distance

telephony. We will not say that ordinary telephonic communication over a thousand miles in America or Australia is impossible, but we will say, and that most emphatically, that at present it is not commercially possible. According to the *Electrical World* of New York the statements of the trials between that city and Chicago, as recently put forward to induce the public to support a new system, have been, to say the least, somewhat garbled. Even supposing them to have been correct, we would respectfully ask what allowance has been made for differences of climatic conditions in England and America by those who talk so glibly about long distance telephony? Progress in telephony is certain, but again the concerted action means "rocks ahead." In many cases the promoters of new companies introduce indefinite statements into their prospectuses in order to bring about a state of unrest in the minds of shareholders in existing companies. We have before us indication of such a state of unrest in the shape of a letter from a gentleman greatly interested in cable companies, who asks whether it is possible that promises recently made as regards telephony can be carried out, and whether telephony is likely to be used in cable work. It is from communications of this character that we are able to trace on every hand the injurious result of the work of the triumvirate. In this case we may say that there is no indication at present of telephony being successfully applied to cable work, and the shareholders of the cable companies may rest content even if telephony could be so applied to-morrow. They have the cables, and telephony *versus* telegraphy most probably means to them a simple change of instruments at the various stations. Instead of fearing the progress of telephony, those interested in cables should carefully watch it, support it, and if ultimately they can use it their expenses will be lessened. For the present, as we have said, the contest is between land telegraphs and telephony. The Government has promised a reduction of rates, which means increased lines, more instruments, and a larger staff, and this in the face of a competition that will grow keener every day. Who can foretell the end?

CORRESPONDENCE.

ELECTRICAL MACHINES AND THE TRANSMISSION OF POWER.

(TRANSLATION.)

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I have only just received the last number of your paper, containing a letter from Mr. Gisbert Kapp, which compels me to ask you to accord me the right of reply in the columns of your next issue. If Mr. Gisbert Kapp considers the letter which you published from me as a joke, he would, perhaps, have done better in letting it pass unnoticed, whilst if he wished to provoke a discussion it would certainly have been worth his while to reply in a courteous manner to the communication which you deemed worthy of notice. Instead of doing this, Mr. G. Kapp stoops to personalities, always out of place in a discussion, and furnishes your readers with a fantastic interpretation of the idea put forward in my letter. It might, indeed, be asked why Mr. Kapp has so little to say on the subject matter of the question raised, and contents himself with demolishing the person of the correspondent who is so unlucky as to be possessed of ideas which do not agree with those of Mr. Kapp, and do not fall in with his long experience.

But to the facts:—

I have said that the general arrangement of the machines at the experiments carried out on the 4th March at the workshops of the Northern Railway, Paris, differed essentially from the conditions necessary to the transmission of power on account of the direct connection between the two machines. I added that M. Hospitalier was struck with a happy thought in drawing the attention of those interested in M. Deprez's experiments to the influence of the derivations of current on the line. I shall permit myself to add to-day, although it will perhaps displease Mr. Kapp, that I think that the results announced since the 4th of March would have been entirely different if the machines had been otherwise connected, and if, in accordance with a desire expressed by one of the committee, an earth connection capable of being connected at will to the wire joining the two machines had been provided. Such is the sense of my comments on M. Deprez's experiments.

I will now pass to the combination I had thought to be able to offer as furnishing, perhaps, a more complete solution of a question which remains, on the whole, an open one. This part of my letter was purely interrogative. I will, therefore, make honourable amends for my ignorance as to the good conditions of working of machines; but I cannot admit that Mr. Kapp destroys the sense of my proposition by disproving the principle on which the fundamental idea was based.

I simply asked if, in the presence of the not very conclusive experiments we know of, it would not be opportune to seek, conjointly with the labours of M. Deprez, the solution of the problem of electrical transmission in "a system composed of two machines differing in type and dimensions; the generator without a core in its armature, and the receiver without wire in the magnetic field, that could be subject to induction [*fil de l'induit*]. (The translator made me say receiver without wire.) The receiving machine should have large dimensions as compared with the generator."

Mr. Kapp indulges in some mild pleasantry on reading the announcement of this combination. I shall therefore try to justify it, so far as it can be justified. The theory set up by M. Deprez led him to construct machines capable of working with relatively small currents, whilst they produced considerable electromotive forces. Now, to obtain a high electromotive force in a dynamo-electric machine without exceeding the speed accepted in practice, it is necessary to increase the length of the induced and inducing wire [*fil induit et du fil inducteur*]. We thus find ourselves between two equally great difficulties: Whether it is best to multiply the turns of wire without changing the size [of the machine], and have machines with fine wire, the resistance of which rapidly increases, which we are trying to avoid; or whether it is best to attempt to diminish the electrical resistance by increasing the diameter of the wire, which will increase the size of the machine to preposterous proportions. Mr. Cabanellas has proved that the influence of speed on eletrical resistance is to be found in machines in the shape of a deficit; but that this deficit of work, of electrical origin, was, so to speak, inappreciable with thick wire machines.

I was thus led to believe that it would be advantageous to make armatures without cores, since one could thus dispose of all the space occupied by this core, which would permit of the winding on of a greater length of thick wire, without changing the size of the machine. Further, by suppressing the core we at the same time get rid of the parasitic actions due to the production of Foucault currents. Thus, if there be no difficulty in constructing machines without cores, we have arrived at this fact; every advantage would accrue from designing these machines as generators for transmitting purposes.

As to the receiver, Mr. Kapp ought to have understood that the expression of which I thought to avail myself in a letter having no scientific pretension could only be attributed to a kind of movable electro-magnet, resembling in its construction the Siemens or Griscom coil. All the electric catechism of which he makes display is, therefore, on this occasion, of no avail (the expression was, perhaps, incomplete, and badly rendered in the translation), since all that I wished to point out may evidently be summed up in this:—Increase the number of turns of wire in the generator at the expense of the size of the core, so as to obtain a greater inductive action and no detrimental parasitic action (Foucault currents),

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and do the opposite in the receiver by favouring the production of magnetic reaction at the expense of direct induction. By this means, as there is no wire in the field, there will be a corresponding reduction in the counter effects. The receiver would not be an induction motor, but a machine (actuated) by successive magnetisations, and by increasing the dimensions of the magnets we can increase the capacity for magnetisation. Moreover, by reducing the distance between the movable armature and the fixed electro-magnets to a minimum, we obtain the maximum effect from the magnetic forces—we utilise them completely.

I think that a movable armature for the receiver, resembling the types I have just indicated, and revolving between suitable electro-magnets, would have a *raison d'être* of its own for power transmitting purposes, since it is known that Griscom's electromotor is benefited by the induced currents which are developed in it. From this to the hope of being able, not to annihilate the counter electromotive force, as Mr. Kapp makes me say, but to regulate [*orienter*] it, in such a manner that its action may not be immediately opposed to the force generated, is but a step. I have made this step and asked myself whether it may not be possible to reduce this loss of power, which is due to the fact that the second machine produces by induction a current which opposes that from the motor; or, whether it is necessary to seek refuge from the dilemma by looking for the increase of the relative work in the decrease of the absolute work, and *vice versâ*? Does Mr. Kapp see any reason why a zealous, though young and innocent disciple of electrical science should not be possessed with such an idea?

We all know that it is impossible to deny the part played by inverse electromotive force. Deprez has illustrated it by a beautiful experiment. We also know that this counter-electromotive force is one of the elements which determines the power developed by the motor; that in this sense it forms an attribute of one of the factors of mechanical work. But precisely because effort takes places, and a path is traversed in doing this work, there would, perhaps, be opportunity for causing the armature to revolve less quickly for a similar path, and for diminishing its inductive reaction by a device which I cannot make known now, and which I can only foreshadow to those who are familiar with the construction of machines. I do not pretend, however, that the solution is easy, nor, indeed, a practical possibility. It is merely a question of finding out whether something cannot be attempted with the view of decreasing the loss due to the production of inverse force, and whether we must always be content with a useful return of from thirty to forty per cent., although the two machines may only be separated by a few metres. Can Mr. Kapp throw light on this question? If he can, I shall yet think myself happy in having been for a space the object of his sarcasm.

I now come to the latter portion of his letter and of mine. I said that the phenomenon which occurs in an electrical system of two machines connected by a conductor is the same as that which we should *observe* in a system with two ventilating fans, acting by centrifugal force, one of which might be [supposed to be] set in motion by means of the air supplied by the other, and both of which might [be supposed to] discharge into [*déboucheraient*] the same pipe. In making use of this conditional style of phraseology, I sufficiently implied that no such system was in existence; Mr. Kapp's insistance on the absurdity of such a mode of transmission has, therefore, no *raison d'être*, and I am surprised that this shadowy sketch of what might be could have led him into error. As to the analogy between the two systems, electric and pneumatic, which my opponent does not recognise, I will demonstrate it, if Mr. Kapp will be good enough to give his address—the letter necessary to do this would be too long and uninteresting for insertion in the columns of your esteemed paper.

I will also show Mr. Kapp, if he wishes, how, in a compound acting fan [*ventilateur à recouvrement*], when one sector passes before the escapement, this sector possesses a dynamical tension, and how this by detent becomes statical. He will then see how it is possible to inflect the indraught current which is generated by the second fan in such a way that it no longer directly neutralises the motion communicated by the first apparatus.

I venture to hope that I shall have succeeded in removing the difficulty so forcibly expressed by Mr. Kapp in his letter, and that he may, perhaps, be less inclined to laugh at efforts such as every one is at liberty to make with a view to solving a question of capital importance.

If, however, Mr. Kapp desires to continue the discussion, he must do so in a courteous manner. I have accepted the lesson he gave me with sufficient grace; it remains for him to make good use of the advice I give.

As one of your most constant readers, I reckon on your kindness for the insertion of this letter as soon as possible.—Yours, &c. A. BANDSEPT, N.F.

Chaussée de Wavre, 15, Bruxelles,
2nd May, 1883.

THE LIGHTING OF NOTTINGHAM.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I believe that your number of May 12 will be found so valuable to electric light engineers as a reference, on account of the three excellent letters of "M. N.," "Henry Lea," and "Edw. H. Winfield," that I trust you will reprint these letters, and attach them to one of the very useful supplements you are from time to time issuing.

I should like to call the attention of your inventive readers to the fifth paragraph of "M. N.'s" letter regarding condensing water, and the train of ideas suggested thereby. It is abundantly clear that if the distribution of electric light and power is to be carried out with currents not exceeding 200 volts E.M.F. (the limits at present fixed by the Board of Trade), every large town will have in its midst a large number of generating centres, at each of which two or three thousand horse-power must be generated by means of steam engines and their boilers.

Now, I have little fear that the persevering genius of modern mechanical engineers will overcome in most cases the difficulties of getting the engines, fuel, feed-water, and, in some cases, condensing water, into the very limited space available as sites for these stations.

But I now ask you—Is there no royal road out of our difficulties? What can the makers of gas engines do for us? Hitherto the gas-engine builders have confined their efforts to comparatively small engines (I believe about sixty horse-power actually given off at the fly-wheel is the largest result yet obtained by Messrs. Crossley Bros.).

Supposing that a gas engine giving off 500 horse-power were available, and could be put down at a cost not exceeding that for a steam engine and boiler of equal size, is it probable that it could be worked at a cost for gas, oil, and attendance of 4d. per horse-power per hour in a town where gas is 2s. per 1,000 cubic feet?

If this question can be answered in the affirmative, it will greatly affect the future of electric light and power distribution, it will convert the gas companies from their position as our rivals to that of our best friends. The gas and the electric undertaking could thus be easily wedded together.

The difficult questions of boiler space, smoke and steam nuisance, transport of fuel, &c., would be avoided, and the desiderata of electric light and power, with gas heating and cooking, introduced into every dwelling house, workshop, and manufactory would be attained.

The gas engine we require for this purpose must be a high speed engine, capable of running direct, coupled to the dynamo, at fully 300 revolutions per minute. It must be perfectly balanced, and there must be no audible or sensible shock from the explosions in the cylinders.

If I am successful in calling the attention of an enlarged circle of thinkers to this interesting problem, my object in writing to you, Sir, will be attained.—Yours, &c.,

London, 17th May. R. E. CROMPTON.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: There is one point in connection with this tender

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which does not appear to have been touched on by any of the critics, although it seems to me to involve an obvious underestimate of the cost of production. I refer to the power stated to be required for each dynamo when running its maximum number of lamps—1,530 indicated horse-power for 15,000 lamps—or say in round numbers one indicated horse-power for each 10 lamps of 20 candles = 200 candles per indicated horse-power. Taking a 50 volt Swan lamp as using 1·4 ampere of current, this gives us 70 watts as the power required for each lamp. If we assume the 70 volt lamps proposed to be employed in the Nottingham installation to take the same power, this gives us $\frac{746}{70} = 10{\cdot}65$ lamps as the theoretical possible per horse-power. Presuming an efficiency of 90 per cent. for the dynamo, 90 per cent. for the lamp, and a loss of current equal to $7\frac{1}{2}$ per cent. on the mains, we get, not 10 lamps as indicated by the specification, but as nearly as may be 8 lamps per effective horse-power, which makes an addition of nearly £2,000 per annum to the coal account.

The proposal to lead two sets of poles to each house is but shirking one of the essential conditions of central station lighting—I mean running the dynamos in multiple arc. The contractors apparently have not thought themselves equal to the task of doing what has been done for months past in New York by Edison at the Pearl-street installation.—Yours, &c., CONTINUOUS CURRENT.

[With reference to the 2,500 hours mentioned in the specification, and criticised by our correspondents last week, we may say that we have been informed that the mills in Nottingham run pretty continuously night and day, and hence the lamp-hours per year would be in excess of those in ordinary towns. We supposed that careful inquiries had been made in Nottingham in order to obtain correct these figures in the specification.—ED. *E.*]

TELEPHONES.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: We notice in your last issue a communication from Mr. Munro, in which he goes considerably out of his way in order to mention our metal microphone in a manner which we must object to as not in accordance with fact.

The metal transmitter patented by us is *not* "a simple hammer and anvil microphone of the kind employed before by Professor Hughes." It might with equal justice be stated that "Professor Hughes's hammer and anvil microphone is a simple contact matter employed before by Philip Reis, the only difference being that one uses platinum, the other carbon."

The experiments of Professor Hughes, when published some five years ago, did not enable any one to construct a perfect transmitter. The effects obtained from the pencil, hammer and anvil, and other microphones, were certainly very startling at first, but it was soon found that to hear the tramp of a fly or the tick of a watch was one thing, while to hear distinct articulation of speech was another. Hundreds of experimenters have tried, and are still trying, to improve the microphone, and we can say from our own experience that it is possible to spend years in the pursuit of this object. If an improvement be ever so insignificant looking, but produces results which the original form was incapable of achieving, the improver has a right to call the improvement by his name. Thus we considered our carbon transmitter to be an improvement upon Professor Hughes's microphone, and we now hold our metal transmitter to be an improvement upon Reis's instrument.

Mr. Munro fears that metal microphones of this kind are not quite practical owing to the adhesion and wasting of the points. We are happy to be able to allay Mr. Munro's fears by the assurance that we easily and surely prevent the adhesion of the contacts in our metal transmitter, and that no wasting of the points can take place, simply because there are no points.

We may mention that one of our transmitters has now been in constant use for the last 14 months without requiring any attention or adjustment.—Yours, &c.,

R. and M. THEILER.

86, Canonbury-road, London, N., 15th May, 1883.

ELECTRIC LIGHTING IN VIENNA.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In the *Daily News* of the 12th inst. a telegram appeared from their special correspondent at Vienna stating that "the day previous the electric light was tried in the Opera House there with complete success. 200 accumulators fed 1,236 lamps distributed all over the theatre."

Since then I have had many communications pointing out that this telegram showed the existence of a successful rival accumulator.

May I, therefore, beg you to be kind enough to announce that the complete success arrived at in the Opera House in Vienna was achieved by Faure-Sellon-Volckmar accumulators constructed in that city by Mr. Lewis Volckmar, one of our electrical engineers, under the auspices of the Anglo-Austrian Brush Electrical Company (Limited).—Yours, &c.,

T. M. COLLET, General Manager.

Electrical Power Storage Company (Limited),
London, May 15, 1883.

THE BRUSH SYSTEM IN ABERDEEN.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: The remark you make in *The Electrician* of the 5th inst., that the electric light in Aberdeen cost six and a-half times as much as gas, will lead to the erroneous conclusion being formed that the supply of electricity on a large scale will be proportionally costly.

The labour charged, for instance, for a small installation such as the one the Brush Company of Scotland erected in Aberdeen is nearly as great as that required to run one of their large dynamos with 40 lights in circuit, and this number of lamps might be increased to 80 or 120 with a still lessened cost per lamp. But, besides this diminution of expense with a large supply, the cost of the Aberdeen street lighting was increased in an exceptional manner by the employment of labour not usual in a 16-light installation. Thus, owing to the boiler being in an adjoining house, the services of an additional man were necessary to stoke, while other expenses were, I believe, incurred in keeping the motor, which was an old type beam engine, in good repair. Every exertion was made by the city gas engineer, who had the motive power under his charge, to render the engine as efficient as it could be made for the unusual work it had to perform.

It does not appear to me extraordinary, therefore, that the expenses should have run up, but I would draw attention to the fact that an installation of this kind, even on the Brush system, which is more economical than others, affords no criterion of the cost under other conditions. For instance, in factories and workshops where steam power is available the engineer, stoker, and special dynamo attendant are not required, and the great part of the maintenance expenses are thus saved. Again, the cost of electricity in a town supply of, say, 50,000 incandescent lights and arc lamps, where all charges will be reduced to a system, with the employment of large dynamos, engines, and labour-saving appliances, cannot be estimated by a trial of this kind.

The use of such an installation is rather to give the people an opportunity of judging the advantages of the electric light, and with this purpose in view the Brush Company of Scotland are now exhibiting in Aberdeen the incandescent system of electric lighting, both direct from the dynamos and by accumulators.—Yours, &c.,

E. W. BECKINGSALE.

Glasgow, May 14.

[We would point out that the statement that the electric light in Aberdeen cost "six and a-half times more" than gas was made by the Gas and Lighting Committee of the

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Town Council of Aberdeen, from whose report we quoted, *vide Electrician* for May 5, p. 579, Vol. X.—Ed. *E.*]

THE GRAMME RING.

TO THE EDITOR OF THE ELECTRICIAN.

Sir: Will you allow me to say a few words on this subject with reference to Dr. Paget Higgs's letter in your impression of the 14th ult.

I venture to think that the results obtained by Dr. Higgs in the experiments he describes do not tend to prove anything either for or against a "screening" action of the core of the Gramme ring.

It is an elementary fact in connection with electro-magnetism that, (1) If a coil of wire is placed in a magnetic field, and a current is produced in the wire by any convenient means, lines of force will either be thrust out of, or concentrated into, the field of the coil, according as the direction of the current is such as to create lines of force of opposite or like direction to those existing in the neighbourhood; and (2) When a current is induced in a coil by the addition of lines of force to its field, the direction of that current is such as to create lines of force of opposite direction to those which produced it.

Now, it is evident from these facts that, if we take a Gramme ring with *no* iron in its core and rotate it in a magnetic field, although when there is no current flowing through it the bulk of the lines of force produced by the field magnets may pass through it, in a sense which would tend to produce an E.M.F., yet a slight current in the coil may be sufficient to thrust them on one side, and practically divide the field of force into two, the greater part of the lines of force lying between the edges of the pole pieces (supposing these to be of the usual form).

In the sketch Fig. 1 is intended to represent the normal condition of the field when no current is flowing through the ring, Fig. 2 the condition when a current is flowing.

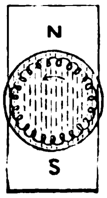


Fig. 1.

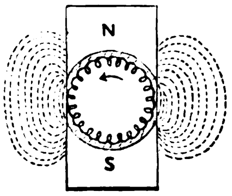


Fig. 2.

If the distances through which the lines of force must pass in order to join the pole pieces in the two cases are compared, it will be seen that they do not differ very materially; consequently a very small force will decide their position.

The presence of a complete iron ring between the pole pieces will have the effect of shortening the distance from one pole piece to the other enormously, and if the ring be large enough to touch the two poles, the external field will be almost inappreciable, the bulk of lines of force passing through the iron ring between the poles. If the ring do not actually touch, the distance separating it from the pole pieces will determine its effectiveness in reducing the external field, or, what is of utmost importance, its effectiveness in concentrating the lines of force into itself. The effect of cutting the core into segments in the manner described by Dr. Higgs is certainly equivalent to increasing the distance by the *sum* of half the distances between the iron segments—probably very much more; and thus we may explain the loss of E.M.F. by considering that the isolated (magnetically) segments of iron are unable to effectively oppose the dispersing action of the current on the magnetic field.

Applying the pole of a magnet in the manner described by Dr. Higgs would naturally have the effect of forcing more of the lines of force into the field of the revolving armature, and consequently increasing the E.M.F.

As regards the question as to whether the inner or outer wire of the ring is most efficacious, I quite agree with those of Mr. Mordey's opinion, *i.e.*, that the E.M.F. is created in the outer halves of each turn; but then it seems to me that if the core is magnetised to saturation by the inductive action of the pole pieces, the E.M.F. created in any one turn for a given speed is at a maximum, *although it is all created in half the wire.*

If we conceive a long soft iron bar, of the same section as the core of the ring, to be magnetised to saturation in such a manner that the poles are the same distance apart as those induced in a Gramme ring, and suppose it to pass through a coil of the same number of turns as the coils on the ring, and to be commutated in the same manner, it seems to me that the E.M.F. created in the coil will be quite independent of the course of the magnetism in the bar, *unless the outer coils can be made to cut more lines of force than those which pass into the bar.* I do not think it is impossible to effect this, but that the number cut in excess of those which pass into the core in the Gramme and kindred machines, as generally constructed, is inconsiderable I think there can be no doubt.

I shall be glad to know the opinion of some of your talented correspondents on this view of the action of the core of the Gramme ring.—Yours, &c., W. B. Sayers.

April 9, 1883.

ON A SIMPLE FORMULA FOR DETERMINING THE INSULATION OF A SECTION OF WIRE, MEASURED THROUGH AN INTERMEDIATE LEAD.*

BY G. A. HAMILTON.

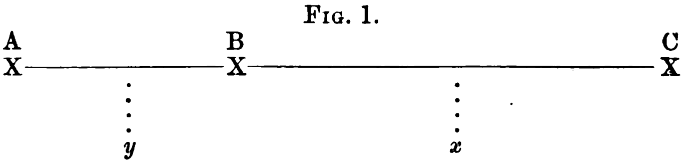
It frequently happens that when the insulation resistance of a section of line or an underground wire or cable is wanted, various impediments prevent reliable measurements from being made at either terminal of the same.

At a cable house it may be the wind or the jar resulting from passing trains along a railroad, the bumping of a ferry boat against the dock, or the inductive disturbance due to the motion of its machinery; or, again, it may be the constant passing of trains along the elevated road that interferes. In some of the cases enumerated it is undoubtedly possible to obtain correct measurements if time is a matter of no consequence, but when it is an important factor the delays and incident annoyances make the measurement of 10, 20, or more conductors anything but a pleasant occupation.

Having experienced all these troubles in and around New York, the writer has made it a practice, in all cases where approximate accuracy is desired, to adopt the old plan of measuring the insulation through a lead of such length as convenience or the circumstances of the case will permit, and at the same time, allow of placing the galvanometer where its indications may be depended upon. The resistance sought is then deduced from the combined results obtained.

As he does not remember of having seen the formula he used outside of his own memoranda, and thinking it may prove interesting to some of the members, he is induced to give its full development herewith:—

Fig. 1.



Let A B (Fig. 1), represent the lead and B C the conductor whose insulation resistance is sought, the conductor resistance in each case being a *small fraction* of the insulation resistance, which latter may be represented by y and x respectively.

Under these circumstances, with A B and B C joined and the end at C insulated, measurements made at A will give the joint insulation of the two conductors, which we will designate by z.

* Paper read before the New York Electrical Society, April 6. Reprinted from the *Operator*.

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Then $z = \dfrac{x\,y}{x + y}$ and the insulation sought will consequently be

$$x = \frac{y\,z}{y - z} \quad . \quad . \quad . \quad . \quad . \quad (1)$$

As x y and z are usually high, measurements by the bridge method are not often practicable, and a mirror or other galvanometer, whose deflections are proportional to the current circulating in its coils, is then generally employed. When this is the case the constant of the instrument must be known. This is obtained in the well-known manner by ascertaining what deflection it gives through a known resistance with a given battery. The resistance sought is then found by placing the same instrument and battery in circuit with it, noting the corresponding deflection and dividing the constant previously obtained by the latter deflection. The quotient is the resistance sought in ohms or megohms, as the case may be.

In using this method for determining the insulation of a section of line through a lead many persons would naturally take the round-about way of finding the resistance of the lead and joint resistance of lead and section tested, separately, and then combine the results as in formula 1. If, however, the combination is first effected, the resulting formula gives the required insulation with very little calculation. This is the plan the writer finds most convenient to practice:—

Let A represent the constant of the instrument, *i.e.*, the resistance through which, with a given battery, it will give one degree deflection;

d, the deflection obtained when the lead, instrument, and battery are in circuit;

D, the deflection when the lead, instrument, battery, and section whose insulation is wanted are in circuit.

The insulation of the lead would then be

$y = \dfrac{A}{d}$ or, if reverse currents are used, as is proper,

$$y = \frac{A}{\dfrac{\Sigma \pm d'}{2}} \quad . \quad . \quad . \quad . \quad . \quad . \quad (2)$$

where Σ is a symbol only, and indicates that the sum of the + and − deflections are to be taken.

The joint insulation of lead and section would, in like manner, be

$$z = \frac{A}{\dfrac{\Sigma \pm D'}{2}} \quad . \quad . \quad . \quad . \quad . \quad . \quad (3)$$

Substituting these values in equation (1), we have

$$x = \frac{\dfrac{A}{\frac{\Sigma \pm d'}{2}} \times \dfrac{A}{\frac{\Sigma \pm D'}{2}}}{\dfrac{A}{\frac{\Sigma \pm d'}{2}} - \dfrac{A}{\frac{\Sigma \pm D'}{2}}} = \frac{\dfrac{4A^2}{\Sigma(\pm d' \times \pm D)'}}{\dfrac{2A}{\Sigma \pm d'} - \dfrac{2A}{\Sigma \pm D'}} \quad . \quad . \quad (4)$$

Dividing by 2A, and multiplying — (both numerator and denominator) by $\Sigma\,(\pm\, d \times \pm\, D)$, the resulting equation takes the form

$$x = \frac{\dfrac{2\,A\,\Sigma\,(\pm\, d' \times \pm\, D')}{\Sigma\,(\pm\, d \times \pm\, D)}}{\Sigma\left\{\left(\dfrac{\pm\, d, \times \pm\, D'}{\pm\, d'}\right) - \left(\dfrac{\pm\, d' \times \pm\, D}{\pm\, D'}\right)\right\}}$$

which on cancellation of common factors becomes

$$x = \frac{2\,A}{\Sigma(\pm\, D' - \pm\, d,} \quad . \quad . \quad . \quad . \quad (5)$$

the most convenient form for use.

In the foregoing illustration a single + and − reading only are taken; if more are used the same should properly appear in the formula, and it is, of course, necessary that a like number of readings should be taken for the lead (whether they do or do not vary) as is taken in the joint measurements.

It will also be understood that when shunts are used they should be accounted for in the formula, as, for instance,

$$x = \frac{2\,A}{\Sigma \pm (D' \times \text{shunt} - \pm\, d' \times \text{shunt})}$$

This is supposed to have been done for A at first.

PRACTICAL TELEPHONY.

[We herewith commence a series of articles upon a subject which, so far as we know, has not yet been touched upon in any electrical publication, viz., practical telephony. These articles are contributed by one who has had a large experience, and, while there is no pretence to literary style, it is hoped that the subject is treated clearly, simply, and exhaustively. —Ed. *E.*]

The Leading-in Wires.—For this purpose No. 18 B.W.G. copper wire, covered with two coatings of gutta percha to a total thickness of No. 7 B.W.G. wound with strong tape, and, lastly, well covered with Stockholm tar, should be used. These wires should be retarred at frequent intervals to keep them in good condition. Paint is injurious to gutta percha. Messrs. Henley and Co. have lately introduced the ozokerit core, which has a slight advantage as regards price, whilst its durability is guaranteed to exceed that of gutta percha. Subjoined is a test of this core by the electrician of the General Post Office, W. H. Preece, Esq., F.R.S.:—

Conductor resistance	23·723 ohms.
Capacity	·281 micro-farad.
Insulation	8,196 megohms.
Temperature	75° Fah.

Tests of gutta percha core of similar length:—

Conductor resistance	22·36 ohms.
Capacity	·273 micro-farad.
Insulation	860 megohms.
Temperature	75° Fah.

It will be seen by this that its insulation is very high, and if it prove to be more durable for telephone leads than gutta percha (which at best is comparatively short-lived when exposed to the air), it should come into general use. It is made by forcing melted ozokerit paraffin into ordinary rubber core under heavy pressure. It would be more economical in the end if the leading-in wires were double-taped; they would then be better able to withstand the rough usage to which they are often subjected from the line men's feet when going up and down the poles, &c. Care should also be taken that a spare piece of gutta percha is wound round them where they touch corners of chimneys, walls, &c. The lead should make a short dip below, and then rise to the hole, where it enters the wall or window-frame, so that rain may run down and drip off at the bend instead of running into the building.

Where possible connect the main gutta percha lead direct to the instrument, it being much less liable to damage. In some cases this may be inadmissible from its unsightliness, when the lead must be joined to the ordinary paraffined wire, and the joint soldered with composite candle or resin. *Never use spirits.* When soldered the joint should be wrapped with tarred or india rubber tape, to prevent contact with other wires.

It may be as well to give instructions here how to solder a joint properly, a very easy operation in itself, although neglected by many fitters. The following articles must be provided:—A small spirit lamp; a small copper bit made from about 2in. of No. 8 copper wire, drawn to a blunt point at one end, with a steel wire screwed into the other, and this wire driven into a brad-awl handle. A small tin box to hold a short piece of composite candle or powdered resin; and, lastly, a small quantity of the best blowpipe solder. The iron, when new, and at intervals afterwards, will require tinning, which is done thus:—Make the iron bright with emery paper, heat it in the spirit lamp, and rub it on a piece of tin with a small piece of solder and composite or resin. This should give it a bright tinned surface. Now, to solder a joint. Scrape the wires bright, twist them firmly together, rub well over with composite, or dust the joint with powdered resin, heat the bit in the lamp, wipe the point with a piece of rag, touch it on the solder so that a small piece adheres, and apply it to the joint, rubbing it along. If this is properly done, a strong, clean joint is the result. This small copper bit

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is sufficient for the small wires used indoors for telephonic purposes.

Terminal Board for Switch Room.—Figures 1, 2, 3, show a convenient terminal board for the leading-in wires. The main board is 6 feet by 3 feet, the terminals are double headed and 3 inches apart in the rows, and the rows 3 inches from each other. The board D is 9 inches wide, and the holes half an inch apart in the rows, and the rows 3 inches apart; in the board E, the holes are half an inch apart both ways. This board will accommodate 200 lines. Each terminal should be plainly numbered on the board on both sides. If the terminal board can be placed in the roof space instead of in the switch room so much the better. The line-man has only to place the gutta percha lead under the desired number. The connections should be complete down to the switch room, and the annunciators in place when the board is first fixed. This saves the instrument fitter visiting the switch room each time a new subscriber is connected.

The Earth Wire.—Too much importance cannot be attached to having a good earth connection, by means of which the circuit is completed. Some people seem to have an idea that any flimsy attachment, such as twisting a wire round the nearest gas-paraffined wire, a stout wire must be soldered to the water-pipe, and the other wire spliced and soldered to it.

It will in most cases be sufficient if the stout wire used for the earth connection starts from the zinc end of the battery. The connection from the zinc to the instrument can be made with paraffined wire.

The Earth Connection for Exchanges.—If it is so important to secure a good earth on ordinary lines, the same holds good with, if possible, increased force to exchanges, for in the case of the ordinary line that only suffers, but if the exchange earth fails perhaps 500 to 1,000 lines are affected. It is therefore advisable to have several earth connections at various points. If possible a large copper wire such as No. 8 B.W.G. should be used. This should be firmly soldered to both gas and water pipes (on the street side of the meter in the case of gas pipes). Do not trust to any bridging, or any makeshift contrivance, and then there will be no risk of having all the exchange business brought to a stand from "bad earth."

It may sometimes occur that an "earth" has to be obtained where there are no water or gas mains. In this case search must be made for a pump pipe leading into a well, which will make a good "earth." Failing this, however, an artificial earth must be

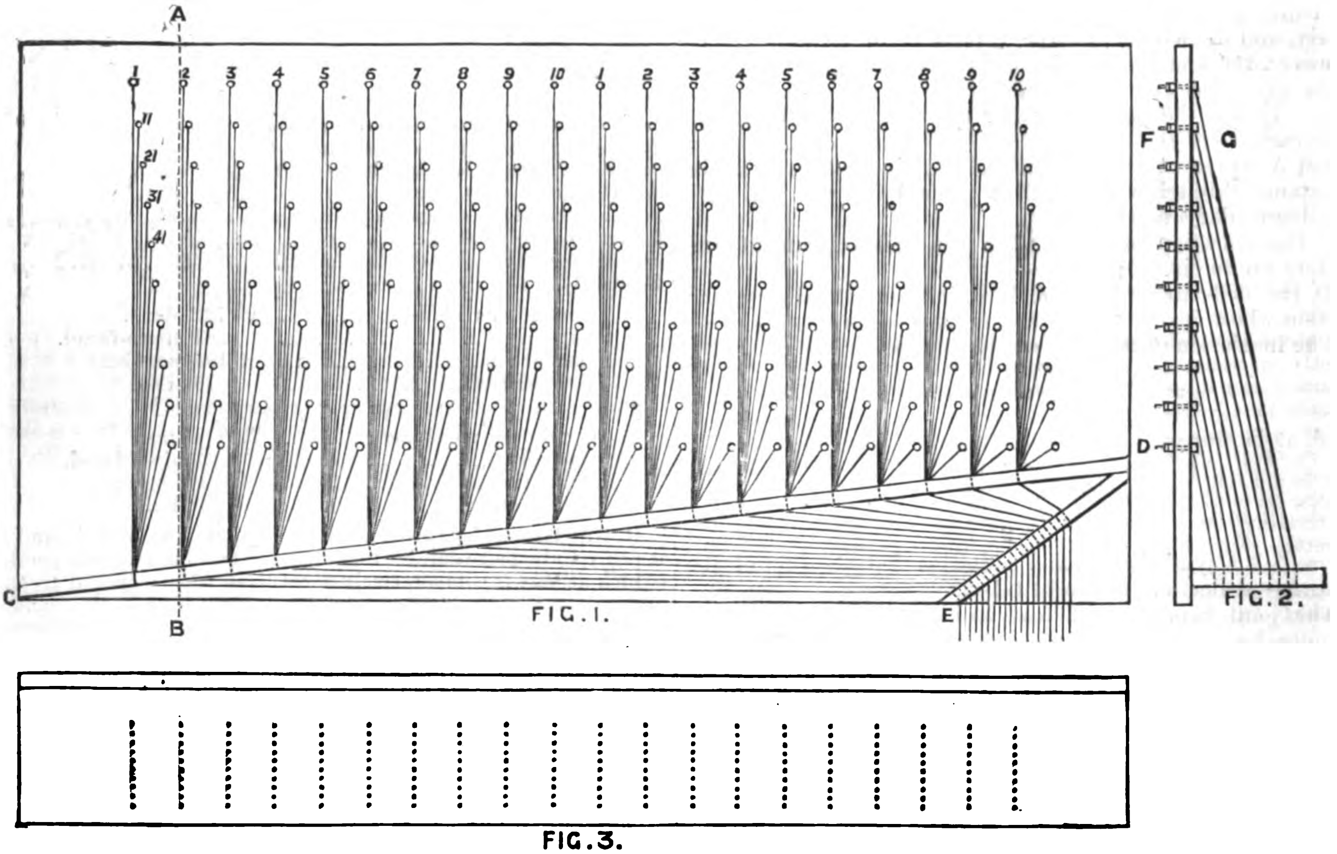

Fig. 1—Elevation of Switch Board; Fig. 2—Section of ditto at A B; Fig. 3—Plan of ditto at C D.

bracket, is sufficient. This, if it answers for a time, is only at the expense of extra battery power, and in all probability causes trouble in calling the exchange, there not being sufficient current passing to drop the annunciator shutter, so, by all means, have a good earth.

If possible, run a gutta percha wire (as used for leads) to the water main (*not a cistern pipe*), scrape the pipe clean, wind the wire (bared of the gutta percha) at least six or eight times round the pipe, bind tightly by drawing the free end under the last three or four coils, and have the whole well soldered together. Failing this, attach to the main gas-pipe, *the street side of the meter* (if on the house side the meter must be bridged over with another piece of wire firmly bound, and soldered on each side), owing to the white or red lead used in the pipe joints making a very bad electrical connection, and composition (*i.e.*, lead) gas pipes should on no account be used. If economy (?) forbids the use of gutta percha covered wire for the earth connection, it is better to use No. 14 or 16 bare copper wire than the small paraffined wire used in connecting up the instruments, because, in all probability, in getting to the water main, the wire must pass places where it will be liable to injury from dampness and other causes; 3-16 galvanised line wire may also be used. If forced to use made thus:—Dig a hole about four feet deep in moist soil (it need not be larger than will enable the workmen to use his tools). Take a strip of about 4lb. of sheet lead, six inches wide and five feet long. Suspend this in the centre of the hole, and fill the hole with tightly-packed gas coke to within six inches of the surface, then fill with the soil to the surface level; the wire must then be soldered to the projecting end of the lead strip.

In some cases where the line is short it may be cheaper to run a second wire and use a metallic circuit.

When testing your earth, test by ringing the bell, and not by the telephone, because the telephone will speak with an "earth" so defective and of such high resistance that the bell could not be made to ring through it.

If it can possibly be avoided, do not have the earth connection on a water main at one end, and on a gas main at the other, as permanent currents are thereby often set up.

The Joining-up Wires.—These usually consist of No. 20 B.W.G. copper wire, having a number of cotton threads laid up parallel with it, the whole well served or bound round with other threads in two colours, so as to show in bands alternately, the whole well saturated with paraffin, and polished by friction. This

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answers the purpose very well, but the insulation is not proof against wet (especially sal-ammoniac solution), therefore, in joining up the battery, take care that the wires or terminals are not wetted by splashing or otherwise, or a fault, or possibly several, will be surely developed in time.

Do not join the wires unless the joints be soldered; joining is seldom necessary, if a wire should be cut too short do not use it, cut another. The short one will come in another time, and, lastly, *never put two wires under one staple, or allow two staples to touch each other.*

In removing the covering from this or any covered wire, never cut square through the covering, but draw the knife parallel with the wire. The first method in all probability makes a slight nick on the wire, and if this is done the wire will come asunder there if slightly bent, and consequently cause a fault.

Lightning Arresters.—If these are used the earth wire in connection with them should, preferably, be separate from the battery earth wire. It should also consist of No. 16 wire right through, or it will be practically useless. It must be well soldered to the main gas or water pipe.

Although, as a rule, in England lightning arresters are seldom used in exchanges, it may be useful to some who may be engaged in other countries where they are absolutely necessary, to know how to protect the instruments under their charge. In the first place, supposing there are no arresters, and warning is given of the approach of a storm, a stout copper wire may be twisted round terminal after terminal all over the terminal board. This, how-

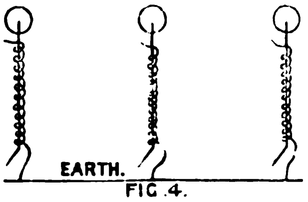

FIG. 4.

ever, stops all operations in the exchange, and must be removed directly the storm is over. The best plan is to insert an arrester to each terminal on the terminal board. A simple arrester may be made thus:—Take two pieces of No. 16 double silk covered copper wire each 6 inches long, and preferably of different colours, twist them firmly together, taking care that the bare ends do not touch each other, test them carefully to see that no leakage takes place between them, fix one end of one wire under the terminal on terminal board, and the end of the other wire to earth. Fig. 4 gives the ideal plan. The two spare ends may be prevented from coming into contact by a covering of sealing wax or shellac. Each line will of course require an arrester. Of course more efficient arresters can be used, but with hundreds of lines the expense is a serious consideration.

The line or earth wires must not be allowed to pass too near lead gas pipes (six inches should be the least distance), as a spark may jump across, fuse the pipe, and fire the gas. This has actually occurred. It should also be remembered that the inductive charge caused by thunder clouds passing over the wires is often powerful enough to fuse the coils of the bells or annunciators, and that short lines are more apt to be affected than long ones.

Lastly, if arresters be used, see that they are carefully made and tested, as there is a risk of communication being interrupted by their leakage to earth.

(TO BE CONTINUED.)

EXPERIMENTAL RESULTS BY SIEMENS AND HALSKE, ON DYNAMO-ELECTRICAL MACHINES WITH CONSTANT TERMINAL E.M.F.

BY ERNST RICHTER.*

The analogy between systems of illumination by gas and by incandescent lamps points to the necessity of contriving some plan under which incandescent lamps may be illuminated and extinguished singly, just as a gas jet may be turned on and off, without affecting the other lights which are fed from the same source. Under the methods hitherto in operation the cutting out of lamps from the system has not been unattended by influence upon the light of the rest, and it has therefore been necessary to counteract this influence by more or less complicated arrangements, as by the introduction of compensating

* Translated from the *Electrotechnische Zeitschrift*, April, 1883.

resistances, which are thrown into the circuit by hand or automatically, by means of electrical regulators, &c.

In the case of an electric machine whose field magnets are excited by a constant current, the brightness of the lamps increases as their number diminishes: and the same thing takes place to a greater degree with machines whose field coils are in a shunt circuit. Lastly, in the case of series machines, as the lamps are gradually taken out the brightness is at first generally increased, then diminishes, and finally sinks so rapidly that below a certain small number the lamps do not burn at all.

If the lamps of any installation are to be capable of being lighted and extinguished singly, they must, in order to be independent of each other, be all arranged in so many parallel circuits, and since the light of each lamp depends upon the difference

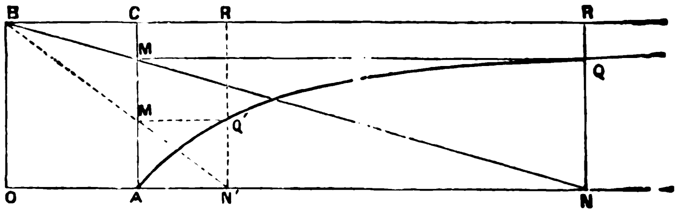

FIG. 1.

of potential at its terminals, they must all possess this E.M.F in the same degree, however many lamps may be in use. In other words, the terminal electrical pressure of the machine at a constant speed must remain constant whatever external resistance is employed. If a machine can be built to satisfy this condition, then all other auxiliary apparatus, whether self-acting or not, will be superfluous, it being only necessary to maintain a constant speed of revolution.

Terminal pressure and E.M.F. are often interchanged and used for one another, but this can properly only be done when the resistance of the machine is so small as to be incomparable with the external resistance, a condition not usually existing. Consequently the E.M.F. of a machine is not constant when the terminal pressure is, and, *vice versâ*, the terminal pressure does not remain the same when the machine possesses a constant E.M.F.

As the question is one of a certain interest it may be well to show how, on the one hand, with a machine with a constant E.M.F., the terminal pressure must change, and how, on the other hand, with a machine whose terminal pressure is maintained constant, the E.M.F. must change.

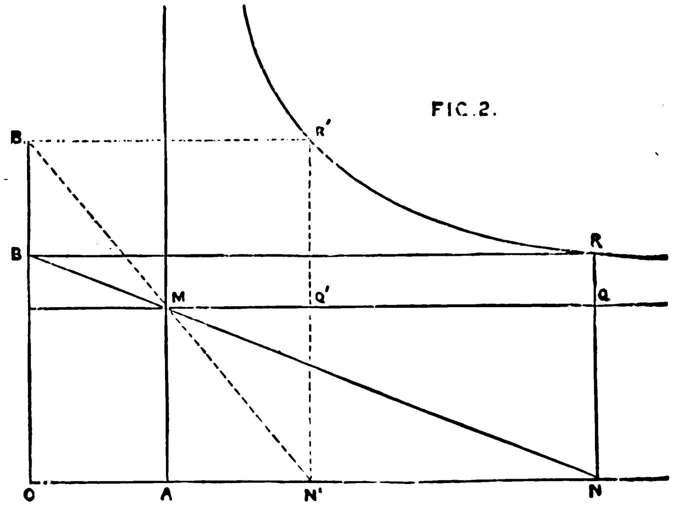

FIG. 2.

(1.) Suppose a machine of constant E.M.F. and internal resistance W_m given. Let the external resistance be W, and the terminal pressure D.

In Fig. 1, if $OA = w_m$, $OB = E$. $AN = w$, then the line BN represents the change of pressure, and $AM = D$. For any other value of w, *e.g.* AN^1, AM^1 represents the terminal pressure. If from every point such as N, a vertical to ON is drawn of such a length as to represent the corresponding value of D, the ends of these verticals will form a curve AQ^1Q, &c., which for all external resistances represents the change in the terminal pressure, while the constant E.M.F. is represented by the horizontal line CR^1R, &c. The equation of the curve of terminal pressure is given by the condition

$$S : w_m = E : (w + w_m) = E : W$$

in which W is the total resistance, and $S = E - D$. From the equation it follows that $SW = EW_m$, that is the product SW is constant, and the curve a rectangular hyperbola, whose asymptotes are the straight lines BO and BR. As the external resistance

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increases from zero, the terminal pressure increases also from zero, at first quickly, then more slowly, and so as to be asymptotic to the value E.

(2). Now, suppose a machine of constant terminal pressure D, and of internal resistance W_m given. Let the external resistance be w, and the E.M.F. be E.

In Figure 2 if $OA = W_m$, $AM = D$, $AN = w$, then $OB = E$.

For any other value of w, *e.g.*, AN^1, OB^1 represents the required E.M.F. If at every point such as N a vertical to O N is drawn of such a length as to represent the corresponding value of E, the ends of these verticals will form a curve, which represents the change of E.M.F. for all values of the external resistance, while the constant terminal pressure is represented by the horizontal line $M Q^1 Q$, &c.

The equation of the curve of E.M.F. is given by the condition:

$$S : w_m = D : w$$

when $S = E - D$; from which it follows that

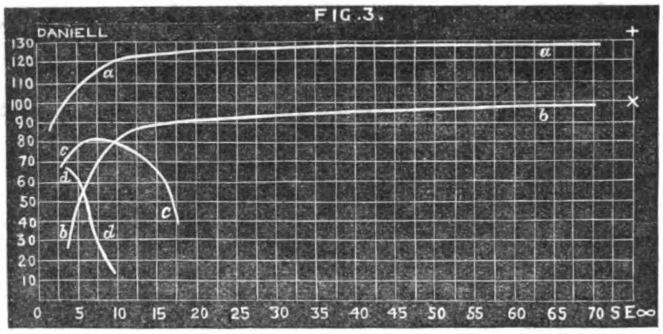
$$S w = D w_m, \text{ or } S w \text{ is a constant,}$$

and the curve is again a rectangular hyperbola, whose asymptotes are the straight lines A M and M Q.

As the external resistance increases from zero, the E.M.F. diminishes from infinity, at first quickly, then more slowly, and so as to be asymptotic to the value D.

Now, to return to the condition described as necessary for incandescent illumination, the terminal pressure, with a constant velocity of rotation, must remain constant under any change of external resistance.

How far this condition has been satisfied in the usual arrangement of electrical machines will be evident from Fig. 3, which represents the curves of terminal pressure in the same machine D_{17} (200) turning with a velocity of 960, under different arrangements of winding and circuit. The curve *a* is plotted under the condition that the field magnets were excited by a constant current of $\frac{17 \text{ Dan.}}{\text{SE}}$. For curve *b*, the electro-magnets were wound with thin wire and put in a shunt parallel with the armature.

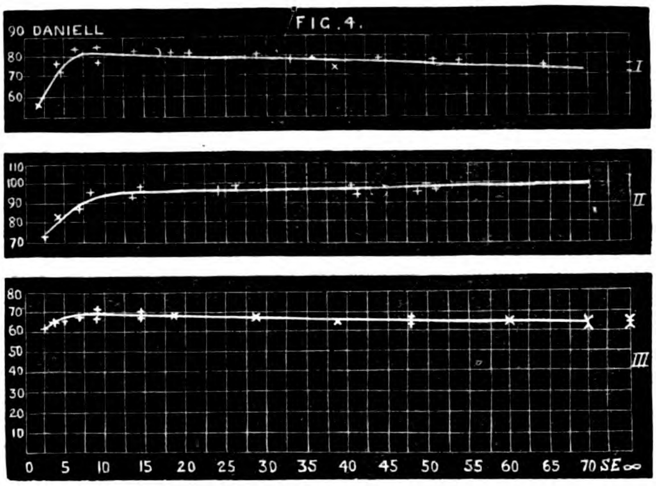


Curve *c* represents the action when the field coils were of thick wire and in series with the moving coils. The ordinates are the measured terminal pressures, the abscissæ the external resistances.

It will be remarked that with an increasing resistance, that is with a diminishing number of lamps, in the curve *b* the pressure increases, that is the brightness of a lamp increases. The curve of terminal pressure of a series machine (curve *c*) changes into curve *d* by an alteration in the winding, and in it the ordinate diminishes with increase of resistance, in contradistinction to curve *b*, in which it increases. The idea to combine these two systems in one machine naturally suggested itself, and hence arose the mixed system of coupling and winding, about which a patent of Messrs. Siemens and Halske was announced on the 20th July, 1882. This patent was withdrawn on the 5th October, as it appeared in the meanwhile that as long ago as 1871 Synsteden, and after him others, had proposed a similar system.

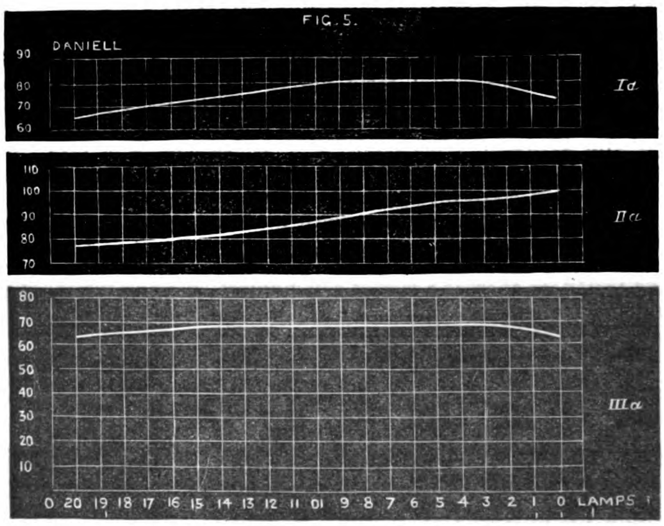
The mixed system has been carried out by Siemens and Halske in various ways. Two of the four electros may receive thin wire, and the other two thick wire, or each of the four may receive two coils, which lie either one over the other, or side by side. The thin wire coils can be coupled parallel with the armature alone, or with the whole machine. The thick wire coil may receive the whole or part of the current. Some of the various results of experimenting with the mixed system of Siemens and Halske are now given.

On the 12th August a dynamo was tested, having two field coils of thin wire, and two of thick. The latter received the whole current, the former were in parallel circuit with the armature. With a fixed speed the terminal pressure was measured, at the same time that the circuit was closed by various external resistances. Curve 1 in Fig. 4 represents the change of terminal pressure, the ordinates representing this quantity, and the abscissæ the external resistances expressed in Siemens's units. The speed was 960. Two cores received each three layers of wire 3·5 mm. diameter, the other two each 19 layers of wire 1·2 mm. diameter. From curve I has been deduced curve I *a* (Fig. 5), in which the abscissæ represent the number of lamps supplied, of 60 Siemens units resistance when warm. This curve is more useful for the present purpose, as it shows clearly how the terminal pressure changes when a given number of lamps are cut out or put in, the number of lamps which give the highest value to the terminal pressure, &c., for which purposes the curves having mere resistances for their abscissæ are not directly serviceable. For representing the external current, the curve having the number



of lamps for abscissæ is also advantageous, for on this plan the curve would more or less approach to a straight line according as the condition of constant terminal pressure was fulfilled more or less perfectly, whereas the curve would approach to a rectangular hyperbola if the external resistances are used for abscissæ.

The curves I and I *a* represent the working of a machine on the 25th August, 1882, before certain members of the German Theatre, and the system of lamps was intended to represent a portion of a theatre installation, in which it is necessary to have the facility of changing at will the number of lamps in use.



On the 3rd September a machine, D_{17} (200), was put to the proof, on which the four cores were each wound with twelve layers of wire of 1·2mm. diameter, and with three layers of wire 3·5mm. diameter. The diagram of the terminal pressure of this machine is represented by curves II. and II.*a*, Figures 4 and 5, and differs from that already considered by continually increasing as the resistance increases, whereas in the former case it falls towards the end. So that with this arrangement the brightness was greatest with one lamp, whereas before it was a maximum with about seven.

On the 10th November the curves III. and III.*a* were given by a machine, D_{17} (200), in which two cores received each two layers of 3·5mm. wire, and the other two each twenty-nine layers of

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1mm. wire. The action was distinguished by a fairly constant terminal pressure, as can be seen from the curves. This pressure slowly increased as lamps are cut out for about four Daniells, then again sinks, and with one lamp has the same value as with the full number, twenty.

The compound system has been since so developed by Siemens and Halske for smaller and larger machines, even to driving 200 A lamps of Edison, that with a constant speed any number of lamps can be put in or out of the system, without affecting the burning of the others. Lastly, it may be mentioned that a machine, $g\ D_{18}$ (250), on the compound system, has been employed since January 9, 1883, in the reading room of the House of Representatives at Berlin every evening to work thirty-two incandescent lamps of Messrs. Siemens Brothers, of Charlottenburg.

A HISTORY OF ELECTRIC TELEGRAPHY TO THE YEAR 1837.

BY J. J. FAHIE.*

Foreshadowing of the Electric Telegraph.

Whatever draws me on,
Or sympathy, or some connatural force,
Powerful at greatest distance to unite,
With secret amity, things of like kind,
By secretest conveyance.
Milton, "Paradise Lost," X., 246. 1667.

Amongst the many flights of imagination, by which genius has often anticipated the achievements of her more deliberate and cautious sister, earth-walking reason, none, perhaps, is more striking than the story of the sympathetic needles, which was so prevalent in the sixteenth, seventeenth, and eighteenth centuries, and which so beautifully foreshadowed the invention of the electric telegraph.† This romantic tale had reference to a sort of magnetic telegraph, based on the sympathy which was supposed to exist between needles that had been touched by the same magnet, or loadstone, whereby an intercourse could be maintained between distant friends, since every movement imparted to one needle would immediately induce, by sympathy, similar movements in the other. As a history of telegraphy would be manifestly incomplete without a reference to this fabulous contrivance, we propose to deal with it at some length in the present chapter.

For the first suggestions of the sympathetic needle telegraph we must go back a very long way, probably to the date of the discovery of the magnet's attraction for iron. At any rate, we believe that we have found traces of it in the working of the oracles of Pagan Greece and Rome. Thus we read in Maimbourg's "Histoire d'Arianisme"‡:—

"Whilst Valens [the Roman Emperor] was at Antioch in his third consulship, in the year 370, several Pagans of distinction with the philosophers who were in so great reputation under Julian, not being able to bear that the empire should continue in the hands of the Christians, consulted privately the demons, by the means of conjurations, in order to know the destiny of the emperor, and who should be his successor, persuading themselves that the oracle would name a person who should restore the worship of the gods. For this purpose they made a three-footed stool of laurel in imitation of the tripos at Delphos, upon which having laid a basin of divers metals they placed the twenty-four letters of the alphabet round it; then one of these philosophers, who was a magician, being wrapped up in a large mantle, and his head covered, holding in one hand vervain, and in the other a ring, which hung at the end of a small thread, pronounced some execrable conjurations in order to invoke the devils; at which the three-footed stool turning round, and the ring moving of itself, and turning from one side to the other over the letters, it caused them to fall upon the table and place themselves near each other, whilst the persons who were present set down the like letters in their table-books, till their answer was delivered in heroic verse, which foretold them that their criminal inquiry would cost them their lives, and that the Furies were waiting for the emperor [he was subsequently burnt alive by the Goths] at Mimas, where he was to die of a horrid kind of death; after which the enchanted ring turning about again over the letters, in order to express the name of him who should succeed the emperor, formed first of all these three characters, TH E O; then having added a D to form THEOD the ring stopped, and was not seen to move any more; at which one of the assistants cried out in a transport of joy, 'We must not doubt any longer of it; Theodorus is the person whom the gods appoint for our emperor.'"

If, as it must be admitted, the *modus operandi* is not here very clear, we can still carry back our subject to the same early date, in citing an experiment on magnetic attractions, which was certainly popular in the days of St. Augustine, 354 to 430.

In his "De Civitate Dei," which was written about 413, he tells us that, being one day on a visit to a bishop named Severus, he saw him take a magnetic stone and hold it under a silver plate, on which he had thrown a piece of iron, which followed exactly all the movements of the hand in which the loadstone was held. He adds that, at the time of his writing, he had under his eyes a vessel filled with water, placed on a table six inches thick, and containing a needle floating on cork, which he could move from side to side according to the movements of a magnetic stone held under the table (pp. 718-9 of the Basileae Ed. of 1522).

Leonardus (Camillus), in his "Speculum Lapidum," &c., 1502, *verbo magnes*, refers to this experiment as one familiar to mariners, and Blasius de Vigenere, in his annotations of Livy, says that a letter might be read through a stone wall three feet thick, by guiding, by means of a loadstone or magnet, the needle of a compass over the letters of the alphabet written in the circumference ("Les Cinq Premiers Livres de Tite Live," Paris, 1576).

From such experiments as these the sympathetic telegraph was but a step, involving only the supposition that the same effects might be possible at a greater distance, but when, or by whom, this step was first taken it is now difficult to say. It has been traced back to Baptista Porta, the celebrated Neapolitan philosopher, and in all probability originated with him; for in the same book in which he announces the conceit he describes the above experiment of St. Augustine, and other "wonders of the magnet;" adding that the impostors of his time abused by these means the credulity of the people, by arranging around a basin of water on which a magnet floated certain words to serve as answers to the questions which superstitious persons might put to them on the future.* He then concludes the 21st chapter with the following words, which, so far as yet discovered, contain the first clear enunciation of the sympathetic needle telegraph:—"Lastly, owing to the convenience afforded by the magnet, persons can converse together through long distances." ("Magiae Naturalis," p. 88. Naples, 1558.) In the edition of 1589 he is even more explicit, and says in the preface to the seventh book:—"I do not fear that with a long absent friend, even though he be confined by prison walls, we can communicate what we wish by means of two compass needles circumscribed with an alphabet."

The next person who mentions this curious notion was Daniel Schwenter, who wrote under the assumed name of Johannes Hercules de Sunde. In his "Steganologia et Steganographia," published at Nurnburg in 1600, he says, p. 127:—"Inasmuch as this is a wonderful secret I have hitherto hesitated about divulging it, and for this reason disguised my remarks in the first edition of my book so as only to be understood by learned chemists and physicians. I will now, however, communicate it for the benefit of the lovers of science generally." He then goes on to describe, in true cabalistic fashion, the preparation of the two compasses, the needles of which were to be made diamond-shaped from the same piece of steel and magnetised by the same magnet, or

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* The author reserves all rights of translation.

† In the dream of the Elector Frederick of Saxony, in 1517, the curious reader may like to discern another dim glimmering, a more shadowy foreshadowing, of the electric telegraph, whose hosts of iron and copper "pens" reach to-day the furthest ends of the earth. In this strange dream Martin Luther appeared writing upon the door of the Palace Chapel at Wittemburg. The pen with which he wrote seemed so long that its feather-end reached to Rome, and ran full tilt against the Pope's tiara, which his Holiness was at the moment wearing. On seeing the danger the cardinals and princes of the state run up to support the tottering crown, and, one after another, tried to break the pen, but tried in vain. It crackled as if made of iron, and could not be broken. While all were wondering at its strength a loud cry arose, and from the monk's long pen issued forth a host of others.—"Electricity and the Electric Telegraph," by Dr. George Wilson, London, 1852, p. 59.

‡ English translation of 1728, by the Rev. W. Webster.

* While it is generally admitted that magnetism has conferred incalculable benefits on mankind (witness only the mariner's compass), we have never yet seen it stated that it has at the same time contributed more to our bamboozlement than any other, we might almost say all, of the physical sciences. With the charlatans in all ages and nations, its mysterious powers have ever been fruitful sources of imposture, sometimes harmless, sometimes not. Thus, from the iron crook of the Greek shepherd, Magnes, and the magnetic mountains of the geographer, Ptolemy, to the magnetic trains of early railway enthusiasts; from the magnetically protected coffin of Confucius, to the magnetically suspended one of Mahomed; from the magnetic powders and potions of the ancients, and the metal discs, rods, and unguents of the old magnetisers, to the magnetic belts of the new—the modern panacea for all the ills that flesh is heir to; from the magnetic telegraphs of the sixteenth century, to the Gary and Hosmer perpetual motors of the nineteenth, *et hoc genus omne*; all these impostures are, or were, based entirely on the (supposed) force of magnetic attraction, to which must be added an unconscionable amount of ignorance or credulity.

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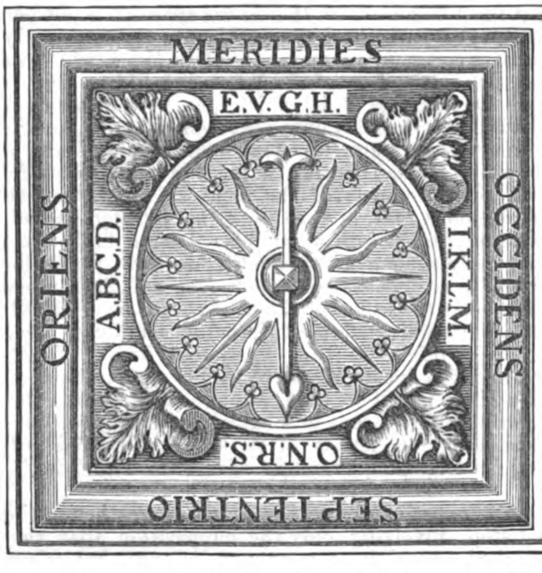
rather, magnets, for there were four, (1), Almagrito; (2), Theamedes; (3), Almaslargont; (4), Calamitro; which imparted south, north, east, and west-turning properties respectively to the needles. The compass-cards were divided off into compartments, each containing four letters of the alphabet, and each letter was indicated by the needle pointing from one to four times to the division in which it stood. Thus the letter C would be indicated by three movements of the needle to the first division of the card. The needles were actuated by bar magnets, or chadids, and attention was called by the ringing of a tiny bell, which was so placed in the way of the needle that at each deflection of the latter it was struck, and so continued to ring until removed by the correspondent.



De Sunde's dial as given in Schott's "Schola Styanographica," copied by kind permission of Mr. Latimer Clark.

The next and most widely known relation of the story occurs in the "Prolusiones Academicæ" (lib. II. prol. 6), of Famianus Strada, a learned Italian Jesuit, first published at Rome in 1617, and often reprinted since. Although the idea did not originate with Strada (for he seems to attribute it to Cardinal Bembo, who died about 1547), he was certainly, as Sir Thomas Browne quaintly says, "The *aeolus* that blew it about," for his "Prolusiones" had long been a favourite classic, while the particular poem referring to the loadstone has, if we may say so, been continually going the rounds of the newspapers. It is quoted more or less fully in many authors of the seventeenth and eighteenth centuries, famous amongst whom are Hakewill ("An Apologie or Declaration of the Power and Providence of God in the Government of the World," 1630), Addison (*Spectator*, No. 241, 1711, and *Guardian*, No. 119, 1713), Akenside ("The Pleasures of Imagination," 1744), and "Misographos" (*The Student, or the Oxford and Cambridge Miscellany*, 1750).

The references to it in the present century are simply too numerous to mention. The following is the latest English version:—

"There is a wonderful kind of magnetic stone to which, if you bring in contact several bodies of iron or dial-pins, from thence they will not only derive a force and motion by which they will always try to turn themselves to the bear which shines near the pole, but, also, by a strange method and fashion between each other, as many dial-pins as have touched that stone; you will see them all agree in the same position and motion, so that, if by chance one of these be observed at Rome, another, although it may be removed a long way off, turns itself in the same direction by a secret law of its nature. Therefore try the experiment, if you desire a friend who is at a distance to know anything to whom no letter could get; take a flat smooth disc, describe round the outside edges of the disc stops, and the first letters of the alphabet, in the order in which boys learn them, and place in the centre, lying horizontally, a dial pin that has touched the magnet, so that, turned easily from thence, it can touch each separate letter that you desire. After the pattern of this one, construct another disc, described with a similar margin, and furnished with a pointer of iron—of iron that has received a motion from the same magnet. Let your friend, about to depart, carry this disc with him, and let it be agreed beforehand at what time, or on what days, he shall observe whether the dial-pin trembles, or what it marks with the indicator. These things being thus arranged, if you desire to address your friend secretly, whom a part of the earth separates far from you, bring your hand to the disc, take hold of the movable iron, here you observe the letters arranged round the whole margin, with stops of which there is need for words, hither direct the iron, and touch with the point the separate letters, now this one, and now the other, whilst, by turning the iron round again and again throughout these, you may distinctly express all the sentiments of your mind.

"Strange, but true! the friend who is far distant sees the movable iron tremble without the touch of any one, and to traverse, now in one, now in another direction; he stands attentive, and observes the leading of the iron, and follows, by collecting the letters from each direction, with which being formed into words, he perceives what may be intended, and learns from the iron as his interpreter. Moreover, when he sees the dial-pin stop, he, in his turn, if he thinks of any things to answer, in the same manner by the letters being touched separately writes back to his friend.

"Oh, I wish this mode of writing may become in use, a letter would travel safer and quicker, fearing no plots of robbers and retarding rivers. The prince, with his own hands, might despatch business for himself. We, the race of scribes, escaped from an inky sea, would dedicate the pen to the Shores of Magnet."

(TO BE CONTINUED.)

ELECTRICITY AS A MOTIVE POWER.*

BY PROFESSOR GEORGE FORBES.

The subject of the transmission of power by electricity has been so often discussed in this room that I have had some difficulty in selecting the point of view from which I should look at the subject to night. I presume that most of my audience have seen the action of a current which was generated by one dynamo acting upon another dynamo so as to cause it to rotate. I presume that they have also seen such a motor driving a circular saw, or a fan, or a sewing machine. They may also have heard of the grand possibilities among which the imagination delights to revel, on the realisation of which we shall look back on the old life without electricity as being but one step removed from barbarism. I propose to myself something more humble, but, perhaps, for all that, quite as useful. That is, to discuss the results which have been already attained, and to show what steps are immediately possible with the knowledge and experience now at our disposal. I will not weary you with descriptions of machines, nor refer to their relative merits. In quoting the performance of any special machine, it will not be so much on account of its merit as because it may have come more especially to my notice in connection with the particular subject which I may be talking of.

Of course, from the moment that Oersted discovered the action of a current on a magnet, it was known that energy could be transmitted to great distances by a wire. The energy which is put in at one end of a telegraph cable is partially reproduced thousands of miles away in the form of mechanical movement. But what we have to consider is the condition of using a current to supply motive power to drive machinery. In what cases is such an application practicable, in what cases is it economical, in what cases convenient? I wish to give you, this evening, an answer to these questions, and to explain what has been done and is being done in this field; how far we can build on past experience, and how far we are justified in foreseeing steps in the future. When new discoveries are made, we are distrustful of them; but we are too often, also, apt to be over-sanguine, and dive, in our imaginations, into the future, and conceive that immediately will be accomplished what experience ought to warn us can only be the result of many decades of labour.

Let me give you an example. We are constantly hearing at present of a certain method by means of which water-power, it is said, will be extensively used. This is to use it in charging accumulators with electricity, and then to carry the accumulators on a tramway or railway, and use them to drive the waggons. At first sight this seems very feasible, but reflection makes us pause. The same water-power has been always available; it might have been used to compress air; compressed air tramcars have been constructed, and in my opinion are a perfect success. This method of application of the water-power is much simpler than by the electrical accumulators, but it has not yet been tried, and hence we cannot hope that this method of using electricity is likely to be very soon introduced.

From the time that it was known that a current of electricity in going through a wire round a rod of iron converts the iron

* Paper read before the Society of Arts on Wednesday, May 2, 1883.

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temporarily into a magnet, inventors have been at work trying to utilise this knowledge in the construction of motors. The chief difficulty lay in the very short distance through which the attraction of a magnet remains powerful. There was also in the motors of old date a difficulty of getting over the dead points. The length of pull of a magnet may be considerably increased by various devices. A somewhat similar action may be effected by utilising the suction of the current through a coil of wire upon a rod of iron. A coil of wire with a current through it acts as a magnet. One end of it attracts the N end of a magnet. But the coil also magnetises a rod of soft iron placed in this position, and having magnetised it, it attracts it.

This principle has been utilised directly to obtain power from electricity. The most interesting application of it which I have seen was at the Electrical Exhibition at Munich last year. That exhibition was especially of interest owing to the various applications of electricity as a motive power, and I shall have occasion to refer to it more than once. The machine to which I now refer is designed by M. Deprez, and is called an electrical hammer. It is intended to perform the same functions as a steam hammer. It consists of a vertical tube containing a short rod of iron, and surrounded with a coil of wire. The wire at each turn is led away to a contact piece on a plate with a movable switch. By this means the current passes only through fifteen turns of the wire. But there are one hundred turns of wire altogether, and by moving the switch you can pass the current through any fifteen you please. You suck the iron into one section, and then move the switch, and so raise the centre of attraction. In this way you suck the iron up to the top of the tube, and then you can equally well drive it down with the force of suction added to the weight of the iron. The weight of the iron was 80lb., the height of the tube one metre. I can illustrate the principle with this model. He used a current of about 36 amperes; 31 amperes was found sufficient when passing fifteen times round to support the weight of the iron. The length of the iron rod was about six times its diameter. This is equivalent to saying that in such a coil a current of one ampere must circulate (15×30^2), or, 13,500 times to support the iron rod in the centre. I tried independently with this small coil, which has three layers of forty-three turns each (129 in all), and I found that five amperes were required to support the iron in the centre. From this result one ampere would have to make 16,200 turns in place of 13,500 as Deprez found. I give these data because they help to fix our ideas, and numerical measurements in magnetism are far more scarce than in electricity. Dr. Werner Siemens has used the same principle in the construction of a motor to be driven by electricity, though I need hardly say his invention was not derived from the one just mentioned. It will readily occur to you that the electrical hammer of M. Deprez might, by a simple modification, be converted into a reciprocating motor, like the piston of a steam engine, and so it might be used to drive a fly-wheel and machinery. But in this mode of applying it, the whole of the momentum of the iron mass would be lost at the end of each stroke. The same is true of the piston of a steam engine. But in the rotary engine it is not the case. Now, although the rotary engine is not so economical as other steam engines, its principle serves to lead us from the electrical hammer of M. Deprez to the beautifully ingenious electric motor of Dr. Werner Siemens. If we suppose the tube with the coil of wire round it to be bent round into a circle, the iron cylinder being also bent into an arc of a circle, then by changing the points of contact for the current to pass through the coils we could suck the iron core round and round inside the circular tube. This is the principle employed by Dr. Werner Siemens in the elegant motor which he has lately produced. The inner iron core is made in the form of a complete ring, but only a certain arc is of iron, the rest is of brass. It rests on wheels, spaces being left in winding the coils for these supports to reach the central ring. In the actual machine the points of contact for the current to enter and leave the coils are changed automatically by the rotating ring. In such a form of motor the magnetism of the iron is never changed or destroyed, and this diminishes largely the waste of energy by heating during magnetising and demagnetising, which is so serious an objection to most motors—I think I might safely say to all other motors.

If this form of motor were used to drive machinery, it is easy to see that, instead of making contact automatically, it would be quite easy to do so by hand, simply turning a handle round; and by doing so, more or less rapidly, the speed of the machinery might be regulated by a boy, with most perfect facility. It could be quickened, slowed, stopped, or reversed, by the simple process of turning the handle. I consider that there will be a great demand in the future for such a form of motor. I will give one example. I am sure many of my audience will sympathise with me when I speak of one of the horrors of a sea-voyage. I refer to the terrors of the steam-winch. What traveller has not spent sleepless nights under the constant influence of the whirring and jarring of that dreadful engine when stowing or discharging cargo. For many years I have felt convinced that this was a field for the application of electricity as a motive power. But for a long time no scheme suggested itself to me which was perfectly satisfactory. In fact, it was not until I saw Dr. Siemens's motor that I felt satisfied that the thing could be accomplished. I have no hesitation in saying that such a motor, with the contacts made by hand, in the manner I have described, will be a very perfect machine, and very much more easily managed than the present steam-winch with its troublesome combination of valves and brakes of multiplying and reversing gear. When such machines are introduced, life on board ship will be a different thing.

Now, I am not going to spend time to-night in describing all the different motors which have been invented. Most motors now in use are simply generators of electricity used in a different way. Many years ago, after a prolonged absence from England in the Pacific, I was writing to the late Professor Clerk Maxwell, and asked him what had been going on in science during my absence. His answer was, "the greatest discovery of late years is that a Gramme machine can be reversed." He saw that this must be a more perfect type of electro-motor than any previous one, and that now there was a real future for employing electricity as a motive power. The Gramme machine was a cheap generator of electricity, and was an efficient motor. The problem was solved, and only required development. Of course, Professor Clerk Maxwell's remarks would have applied to any other of the modern generators. I am not going to trouble you with a description of these machines; their construction is known to most of you. It suffices to say that, when one machine is turned so as to give a current, it can drive another machine at a distance.

Now let me say a few words about the convenience of electrical motors. We are certainly a long way from having electricity laid on to our houses, like water, which we may use for any purpose we please. But when it is laid on, it is certain that many people will use it, because they now use water-engines, although water is very expensive, and because electric motors would be far more convenient in many ways. But in a large factory the only method available for distributing power is either by shafting or by steam-pipes. Both of these are objectionable in many ways, and the convenience of having only to lead wires to the different places where power is required will in time become manifest to many of our manufacturers. This remark applies more especially to donkey-engines and steam-steering apparatus on board ships; and I confiently look forward to electricity being largely used for the light work on steamers, and this before very long. Of course special attention will be given to see that the compasses are not affected by the powerful magnets and currents used for these purposes.

It is found that to get any good effect an electric motor must run at a high speed. In this, there is a great difference between the theory of electro-motors and of steam engines. If a steam locomotive were restrained from running down an incline by the pressure of steam on its piston, the steam would be doing no work, and no power would be used up, except by a slight condensation. But if an electric locomotive were to perform the same office, it would be using up the current all the time, and yet not performing external work. When with the electrical hammer the iron cylinder is supported in the tube by the electric current, power is being used up, and yet no external work is done. It is the same as with muscular exertion. This introduces us to a new factor in mechanics, the cost of the statical effort. When I support a weight, I am using up muscular energy, and yet I am doing no external work.

But there is one peculiarity in electric machines of great importance. The motor is also a generator. Thence it follows that, when it is in motion, it creates an electromotive force. This tends to produce a current of electricity in the circuit, going in the opposite direction to the one which is driving the motor. The intensity of this opposing force is directly proportional to the velocity of rotation. If the generator and motor were identical, and the work done by the motor was so far reduced as to allow it to rotate nearly as fast as the generator, then the opposing electromotive force would almost be equal to that of the generator, and there would be hardly any current in the circuit. But if a brake be put upon the motor, more work is done, and the current in the circuit increases. The maximum amount of work is got from a motor in this way when the counter electromotive force is equal to half that of the generator. The greatest efficiency (or return) is obtained when the counter electromotive force is nearly equal to that of the generator. Some persons have argued from this that we ought to run motors with very light loads for the sake of economy. This is not the case. If the motors were run so as to do only half of the maximum, we should require twice as many motors, and usually the prime cost of the motors

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is too great to cause this to be economy. The efficiency of a generator for electric lighting or other purposes is highest when there is a very high resistance in the circuit, but electricians, as a matter of fact, nearly always work their dynamos up to their maximum capacity, although this is by no means the most economical, so far as the efficiency is concerned.

(TO BE CONTINUED.)

MEETING OF THE SOCIETY OF TELEGRAPH ENGINEERS AND OF ELECTRICIANS.

MAY 10, 1883.

The proceedings commenced with a description of "The Electric Holophote Course Indicator" by its inventor, Mr. J. H. A. Macdonald, Q.C., associate of the society. This appliance, which was explained and illustrated in our issue of April 8, 1882, is designed to prevent collisions at sea by means of electric light signalling, and not only indicates the course a vessel is steering, but is free from liability of error on the part of the look-out men. An electric light is operated upon in connection with the helm, and to some extent acts automatically in conformity with the tack upon which the vessel is being steered. In view of the greatly increased speed of marine travelling, the crowded state of the courses usually followed, and the unwieldy dimensions of most ocean steamers nowadays, the risks of colliding and the difficulties of avoiding it, while the existing imperfect method of signalling prevails, were daily increasing, and the necessity for some better system was becoming more and more urgent. A penetrating arc light, supplemented in foggy weather by an electric bell, as devised by Mr. Macdonald, would greatly increase the distance between which vessels could sight each other, and would unerringly indicate the course they were respectively steering.

The remainder of the evening was occupied by Professors W. E. Ayrton, F.R.S., and John Perry, who laid before the society the results of a number of recent experiments instituted by them to test the efficiency of electro-motors, and the best method of governing them. The advantages of employing such motors were manifold. They saved gearing and shafting, their distance from the prime mover could be far greater, and their light weight and consequent portability gave them a great superiority. There was still, however, to be determined the best form of motor for given circumstances, and the best means of regulating speed according as the machine was doing little or much work. Many different machines had been tested with a view, first, to find out what relation their power bore to their dimension. The electrical resistance, the mechanical friction, and magnetic friction being ascertained, there remained the useful work given out, which could be ascertained pretty accurately if care were taken to guard against the dynamometer itself causing friction. The first motor examined was the little one called "The Griscom" weighing about two pounds; and this was found to yield 17 per cent. of the power put into it. Of course in this and the following tests it was necessary first to settle what was the greatest power that could be used, that is to say the most powerful current practically applicable without abnormal heating. It was found that current depends on load and speed; and, contrary to what had been stated elsewhere, it also increases with the speed if the load is constant. The next motor examined was one weighing 8lbs., being a Gramme armature with a Siemens field magnet. The efficiency of this was 20 per cent. The Jablochkoff motor yielded only an efficiency of 3·7 per cent, though its weight was two or three times greater than that of the motors previously mentioned, the fact being that well nigh all the faults that could be got into a given space were conspicuously present in this motor. A motor similar to the second one, but weighing 30lbs., showed an efficiency of 26 per cent., in another experiment the efficiency reaching 32 per cent. Thirty per cent. efficiency was obtained from a motor of their own weighing 36lbs., the useful horse-power given out being about a quarter horse-power. Here it became very noticable that while the power per weight of motor increases with the weight to a certain, though not very marked, extent, the efficiency went on increasing enormously as the motors tested became heavier. Another motor of Professors Ayrton and Perry showed an efficiency of 49 per cent., its weight being 75lbs. A De Meritens weighing 72lbs. gave 50 per cent. of efficiency; whilst a large Siemens motor the weight of which was 519lbs., yielded 71 per cent. and in another experiment 75 per cent. The remainder of the discourse was occupied with descriptions of the best form of governor applicable to motors of this class, and with mathematical proof of the correctness of the data arrived at in the several experiments described. Proof was also adduced of the increase in the resistance of an armature due to self-induction—so much so that the armature will stop and revolve in an opposite direction when the current is suddenly cut off. On this point an opinion was strongly expressed that the proportions usually maintained between armatures and field magnets in manufacturing such apparatus are not the best for securing the best results. After the meeting several motors were seen at work, the power for which was supplied by 40 of the half horse-power accumulators kindly lent for the occasion by the Storage Company.

LONDON PLATINO-BRAZILIAN TELEGRAPH COMPANY (LIMITED).

Report of the directors to be presented at the fifth ordinary general meeting to be held at the offices of the Company on the 31st May:—The balance-sheet and other accounts for the past financial year are submitted herewith; they are made up on the same principle as those last laid before the shareholders. The net revenue of the year, after providing for debenture interest and income-tax, is £9,083 4s. 7d., and £7,583 19s. 6d. is brought from the preceding year's account, making a total of £16,667 4s. 1d. to the credit of the revenue account. The interim dividend of two shillings and sixpence per share, paid on November 19th, 1882, absorbed £4,793 10s., leaving to be dealt with £11,873 14s. 1d., from which the directors propose to appropriate £5,752 4s. in payment of a final dividend of three shillings per share, being at the rate of 2¾ per cent. per annum, and carrying forward £6,121 10s. 1d., pending the collection of the debt due from the Uruguay Government. Active steps are still being taken to induce a proper consideration and settlement of the claim of the Company from that government. The inequitable competition referred to in the last report between the Brazilian Government land lines and the cable system of the Western and Brazilian Company, from which system this Company mainly derives its revenue, still continues. The land line traffic shows a small increase, but the receipts cover an amount not yet paid by the Government of Uruguay for their current messages. The submarine cables and land lines are in good working order. According to the Articles of Association, John Pender, Esq., M.P., a director of the Company, retires by rotation, and offers himself for re-election. Messrs. Deloitte, Dever, Griffiths, and Co., the auditors, retire at this meeting, but being eligible, offer themselves for re-election.

COMPANIES' SHARE LIST.

TELEGRAPHS.

Companies.	Closing Prices May 16.		Business Done Week Ending May 16. Highest.	Lowest.
Anglo American	50½,	51½	—	—
Do. Preferred	82½,	83½	84	83
Do. Deferred	20½,	21	21½	20½
Brazil Submarine	12½,	12¾	12¾	12½
Cuba	10,	10½	10⅝	10 5-16
Do. Preference	17,	18	—	—
Direct Spanish	5¾,	6¼	6 1-16	5¾
Do. Preference	16¼,	16¾	16⅝	16½
Direct United States Cable	12½,	12¾	12 15-16	12¾
Eastern Telegraph	10¾,	11	11	10⅞
Do. 6 per Cent. Preference	13¼,	13¾	—	—
Do. 5 per Cent. Debentures, 1899	104,	107	107	105
Eastern Extension	12,	12½	12 1-16	12 1-16
German Union	10,	10½	—	—
Globe Telegraph and Trust Company.	7,	7¼	7 3-16	7 1-16
Do. Preference	12¾,	13	13 1-16	12¾
Great Northern	12¾,	13	12⅞	12⅝
Indo-European	31½,	32½	—	—
Mediterranean Extension	1½,	2	—	—
Do. Preference	6,	7	—	—
Reuter's	9½,	10	—	—
Submarine	247,	252	—	—
West India and Panama	1¼,	1¾	—	—
Do. 1st Preference	7¼,	7¾	—	—
Western Brazilian	6¾,	7¼	—	—
West. Union 7 per Cent. 1st Mortgage	122,	124	—	—
Do. 6 per Cent. Sterling Bonds	103,	106	—	—

TELEPHONES.

Consol. Telephone and Maintenance	⅝,	⅞	⅞	⅞
Oriental	½,	¾	11-16	⅝
United Telephone	9½,	9¾	9⅝	9½

ELECTRIC LIGHT.

Anglo-American Brush Lgt. (£7 paid).	2¾,	3¼	3 7-16	2¾
Do. (fully paid)	5,	6	6 3-16	5½
Hammond Light	2½,	3	3	2 3-16
Pilsen, Joel, and General Electric	¼,	⅜	—	—
Swan	1¾,	2	1⅞	1¾
Maxim-Weston	⅛,	⅜	¼	⅛

TRAFFIC RECEIPTS FOR APRIL, 1883.

Companies.	April, 1883.	April, 1882.	Incrse.	Decrs.
Cuba Submarine Company	3,900	3,921	—	21
Direct Spanish Telegraph Company	1,766	1,824	—	58
Eastern Telegraph Company	45,148	42,667	2,481	—
Eastern Extension Telegraph Company	32,005	29,269	2,736	—
Great Northern Telegraph Company	20,400	—	—	—

WEST INDIA AND PANAMA TELEGRAPH COMPANY.—According to the report of the directors, the receipts for the six months ending 31st December, 1882, amounted to £40,273, and the expenses to £26,693, leaving a balance of £21,201, including £7,621 brought forward. Having in view the small amount of the reserve fund, and the extent of the Company's cables, many of which have been submerged twelve years, the board cannot recommend any payment on account of dividend. They have placed £15,000 to reserve, bringing up that account to £61,843, and recommend that the balance be carried forward. Reference is made to the proposal of the Barbadoes Conference to establish a competing system of cables, which the Home Government has rejected, and it is added that the Company have laid before the Earl of Derby a scheme for strengthening the telegraphic connections of the West Indies.

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NOTES.

HOLBORN.—The Edison Electric Light Company have withdrawn their application for a provisional order for the Holborn district.

CANADA.—Recent news from the Dominion stated that a committee had adopted the Canada Rapid Telegraph Company Bill, in opposition to the Government.

WIRES AND POLES IN BROOKLYN (NEW YORK).—A recent report states that there are 2,500 miles of wire and over 5,000 telegraph and telephone poles in Brooklyn.

NEW CABLE BETWEEN HONG-KONG AND SHANGHAI.—The Eastern Extension Telegraph Company notify that their new cable between Hong-Kong and Shanghai is now open for traffic.

ELECTRIC LIGHTING IN NEW YORK.—A Bill has passed the New York Senate, authorising the commissioner of the new capitol to complete arrangements for lighting it with electricity.

ANGLO-AMERICAN BRUSH CORPORATION.—It is stated that Lord Thurlow has accepted the chairmanship of this corporation, and that Mr. Herbert C. Gibbs has also joined the Board.

THE ROYAL SOCIETY.—Mr. W. H. Preece, F.R.S., was o read his second paper on "The Effects of Temperature on the Electromotive Force and Resistance of Batteries" before this society on Thursday last.

THE DEVELOPMENT OF ELECTRIC LIGHTING.—This was the title of a paper read on Thursday night, at the Society of Arts, by Mr. J. E. H. Gordon. We shall have more to say about it in our next issue.

SECONDARY BATTERIES.—On Monday last Dr. O. J. Lodge delivered the first of two Cantor Lectures on Secondary Batteries at the Society of Arts. We shall hope to print these lectures at no distant date.

LAND LINES IN CHINA.—A Reuter's telegram dated Hong Kong, April 14, *viâ* San Francisco, says:—"The telegraph line between this city and Canton has been completed, but is not yet open for traffic."

ELECTRIC LIGHTING FOR FULHAM.—The West Middlesex Electric Lighting Company have applied to the Board of Trade for a license to supply electricity for lighting and other purposes in the Fulham District.

TO BE WOUND UP.—A petition for the winding up of the Railway and Electric Appliances Company was presented on the 17th inst., and is to be heard to-day (Saturday) before Vice-Chancellor Sir James Bacon.

ELECTRIC LIGHTING IN LOS ANGELES.—An American contemporary states that the inhabitants of Los Angeles, in California, are highly gratified with the lighting of their city by means of Brush lamps placed on masts 155ft. high.

ELECTRIC LIGHTING FOR THE WEST END.—The St. George's (Hanover-square) Vestry have agreed to support the provisional orders applied for by the Swan and Metropolitan Brush Companies to supply electricity in their parish.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY.—The traffic receipts of this company for the week ending 18th May, 1883, were £1,941, after deducting the "fifth" of the gross receipts payable to the London Platino-Brazilian Telegraph Company.

M. PHILIPPART.—A telegram from Brussels, dated May 21, says: "The Brussels Court of Appeal has again rejected the demand of M. Philippart to be set provisionally at liberty. This proves that the charges against him are of a very serious nature."

THE TELEPHONE IN PARIS.—On the 1st of this month the number of subscribers to the exchanges of the Societé Générale des Téléphones in Paris was 2,840. The number of calls per week at the same date had risen to 100,000. The number of subscribers to country exchanges was 4,460.

UNDERGROUND WIRES IN NEW YORK.—The Common Council of New York has given permission to the Western Union Telegraph Company to lay its wires under the streets of the city on the payment of one cent. per lineal foot of each street opened and the giving of two wires for the city's use.

ELECTRIC RAILWAY AT FRANKFORT.—It is stated that an electric railway is being constructed between Frankfort-on-the-Main and Offenbach, a neighbouring town, distant about five kilometres (about eight miles). The steam engines and dynamos are to be located at a village named Oberrod, half way between the two towns.

ELECTRIC LIGHT IN MINERAL WATER WORKS.—An installation of a Lumley dynamo machine and sixty Woodhouse and Rawson incandescent lamps has just been put up at Messrs. Barrett's mineral water works by the Lumley Electric Light Co. Messrs. Woodhouse and Rawson were appointed contractors for carrying out the work.

ELECTROLYTIC BALANCE OF CHEMICAL CORROSION.—Dr. G. Gore's papers on this subject read before the Birmingham Philosophical Society have been reprinted from the *Proceedings* of that body in pamphlet form. They occupy some 60 pages of 8vo. An abstract of one of them was given in our issue of 3rd March last, p. 381, Vol. X.

SCIENTIFIC QUESTIONS OF THE PRESENT.—Under the title of "Some Scientific and Technical Questions of the Present" Mr. Julius Springer, of Berlin, has published, in German, some of the more recent addresses and lectures of Sir William Siemens, notably his address as President of the British Association and at the Society of Arts.

A LONG-LIVED LAMP.—A contemporary states, on the authority of the Edison Co., that one of the B (8 candle) lamps used in the Strasburg station installation has been burning over 5,000 hours. The same source also states that the company's manager intends to make a series of experiments with this lamp, and to publish the results.

OVERHEAD WIRES IN WANDSWORTH.—The Wandsworth Board of Works have decided to take counsel's advice as to certain overhead telephone wires that have been erected in their parish, and have also authorised their clerk to agree with the solicitor to the Post Office upon a test case with reference to some of the Department's overhead wires.

PADDINGTON.—After due consideration of the provisional order applied for by the Metropolitan Brush Company, the Paddington Vestry have passed a resolution to the effect that they are of opinion that the question of electric lighting requires further consideration, and empowering their solicitor to take the necessary steps for opposing its introduction into the parish.

THE EDISON SYSTEM IN BRUSSELS.—The Edison Company of Brussels has applied to the municipal authorities of that city for a concession empowering it to light by electricity the interiors in a district which includes several theatres, cafés, and large commercial establishments, but the College of Burgomasters and Echerins has taken time to consider the application.

ELECTRIC RAILWAY COMPANY.—The Electrical Railway Company of the United States was incorporated at Albany, New York on the 8th inst. Amongst the incorporators we

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notice the name of Thomas A. Edison. The company has been formed to work a system based on the patents of Mr. S. D. Field and Mr. T. A. Edison. The capital is two million dollars.

Appointment.—Mr. W. Hammer has been appointed electrical engineer to the German Edison Co. of Berlin. Mr. Hammer came over to London with the first set of Edison machinery, and took an active part in perfecting the central station on Holborn Viaduct. His energy and ability are well known, and, we have no doubt, will soon be felt in the new field of labour before him.

Electric Lighting in Hartford (America).—The Hartford Electric Light Company has submitted to the city authorities a plan to light the entire city, and the proposition, in official form, will be laid before the council at its meeting two weeks hence. According to this plan a saving of 8,000dols. will be effected, and the city better lighted.—*Sanitary Engineer*, New York.

Electric Lighting for the City.—At the last meeting of the Commissioners of Sewers, the chairman stated, in reply to a question from Mr. Innes, that the question of introducing the electric light into the City was well in hand, that reports were being prepared, and a specification got ready by a gentleman appointed for that purpose, and that in a very short time he thought the matter would be in proper shape for dealing with it.

Sixpenny Telegrams.—A long article on this subject appeared in *The Times*, of the 21st instant, under the heading, "Cheap Telegrams." As the question has been so fully and so frequently treated in our columns we need not make any lengthy extracts from this article. It concludes by advocating the extension of the pneumatic system as offering facilities for an even greater reduction in the rates for the transmission of telegrams.

Incandescent Lamps.—Mr. C. F. Brush has patented a device by which he hopes to preserve the filaments of incandescent lamps from what has been called "molecular bombardment." He inserts a screen of mica between the legs of the filament, and thinks thereby to intercept the minute particles of carbon which are torn off and propelled from one leg against the other, a process which eventually weakens and aids in the destruction of the filament.

The Telephones and Thunderstorms.—Statements have reached us from several different quarters of the alarming and even dangerous phenomena experienced by the users of telephones during a recent thunderstorm. Vivid flashes were seen to emerge from the apparatus, which in some cases was completely disabled. Our informants complain that no proper provision is made to carry the lightning current to earth before it enters the users' premises.

Electric Lighting in Leeds.—At a meeting of the Electric Lighting Committee of the Town Council of Leeds, held on Monday, plans and specifications for the proposed lighting of portions of the new municipal buildings, &c., were submitted and approved, and tenders ordered to be invited. These are to be sent in by the 21st June. As we publish the specification and other information in another part of the paper, we need not refer to this matter at any greater length here.

The Telephone in the East.—The Oriental Telephone Company have transferred their business in Egypt to the Telephone Company of Egypt for £60,000 in 12,000 fully paid-up Ordinary shares and 4,000 Deferred shares in the new undertaking. A company has also been formed in Calcutta to embrace the whole of the Bengal Presidency, and the Oriental will receive in payment for its rights Rs.1,30,000 in cash, Rs.2,50,000 in "A" or Preferred shares, and Rs.3,80,000 in Deferred shares.

Glasgow College of Science and Arts.—The annual distribution of prizes to the students of this college took place on Monday last. The chair was occupied by Mr. J. H Stoddart. The first prize for magnetism and electricity in the Senior Division of the Electrical Engineering Classes was taken by B. Conner, and in the Junior Division by O Rennie and J. R. C. Honeyman, bracketed equal. In electric lighting J. Sharp was first, and in telegraphy, W. Fulton, of the Glasgow Post Office.

Electric Lighting on Ships.—The "Ipswich," which was launched this week at Earle's Engineering and Shipbuilding Company's yard, Hull, is to have all her first class accommodation lighted by means of incandescent lamps. She has been built for the Great Eastern Railway Company's service between Harwich and Rotterdam. This company are always on the look out for anything that can contribute to the comfort of their passengers, and certainly their Continental service is a capital one, as we have often had occasion to find.

Westminster.—The Westminster Board of Works have been engaged in a correspondence warfare with the Board of Trade with reference to an extension of the time for considering provisional orders. The opposition they have offered has drawn down upon them a reminder from the Board of Trade that they are as much bound by the Electric Lighting Act as the companies, and that in the event of such opposition being continued the Board of Trade may have to ride the high horse. The District Board are to hold a special meeting soon to further consider the matter.

The Faure Electric Accumulator Company.—Mr. Harcourt Turner has addressed a circular to the shareholders in this company, reminding them that certain statements made by M. Philippart in December last have not yet been verified. That no date has been fixed for the holding of the annual meeting, although it had been stated that it would be held about the middle of this month. That their chairman is under arrest, and that, with a view, if possible, of determining what is to become of them, he has engaged a room at Cannon-street Hotel, for one o'clock, on the 29th instant, when he hopes as many as can will meet him.

The Czar's Coronation.—The following description of the lighting of the Kremlin was given by the *Daily News* correspondent:—"Early this morning (May 18) I was invited by Mr. Gustav Last, the contractor for the lighting of the Kremlin by electricity, to assist at a dress rehearsal of the illumination. The Ivan Veliki Church was entirely enamelled with 3,500 Edison incandescent lamps, worked at a distance of 1,000 yards by engines of Hornsby and Sons, of Grantham, representing 170 horse-power. As the outline of the cupola began to glow into light the effect was magical, but when the entire church, with its three towers and façade, revealed its full brilliancy it seemed in the black night an incandescent mirage or some strange meteors appearing in the silence of the sleeping city."

New Electrical Commutator.—M. E. Renoult has devised a new key for putting an electrical appliance in circuit, or withdrawing it, without interrupting the current. It consists of two copper plates, insulated by a block of wood, to which they are attached. The main leads are attached, by binding screws or otherwise, to the copper plates at one end, while the other is left free, in the form of a fork, capable of being readily attached to two other copper plates insulated from each other and connected with the leading wires, which

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put the appliance in circuit. To break contact with these two last-named leads, the fork is withdrawn, while at the same time the circuit is closed by means of a screw carrying on its axis a movable metal plate. In this way the continuity of the current is maintained, while the original resistance is re-established.

INFLUENCE OF TEMPERING ON THE ELECTRICAL RESISTANCE OF GLASS.—M. Jamin lately brought before the Académie des Sciences, Paris, some observations made by M. Foussereau on the influence exercised by the process of tempering on the electrical resistance of glass. The experiments made by this gentleman lead him to the following conclusions:—1. Tempering diminishes, in a considerable degree, the electrical resistance of different varieties of glass. 2. A moderate annealing, sufficient to partially dispel the elasticity due to tempering, diminishes only in a partial degree the influence of tempering on the electrical resistance. 3. The electrical resistance of glass recently annealed continues to increase slowly during a certain period, as if its molecules gradually approached a condition of definite equilibrium; and the electrical resistance of glass, whether tempered or not, which has not been lately heated, remains constant.

NEW EXPERIMENT IN ELECTROLYSIS.—In a recent number of the *Comptes Rendus* M. E. Semmola describes a new experiment in electrolysis. The apparatus consists of a voltameter having three electrodes arranged in the form of an equilateral triangle, with a tube over each electrode. One of the electrodes, *c*, is connected with the positive pole of the battery, the other two, *a* and *b*, being connected with the negative pole by means of a commutator, which is so arranged that the current can be sent entirely through *a* or *b*, or can be separated and sent partly through *a* and partly through *b*. The sum of the volumes of hydrogen collected in the two tubes, when the current is thus separated, is equal to the volume collected in a single tube when the current is sent entirely through one of the electrodes *a* and *b*, thus proving by means of a single voltameter that the same quantity of electricity always produces the same amount of chemical decomposition.

THE PORTRUSH ELECTRIC TRAMWAY.—The *Glasgow Herald* says in a recent issue:—"A few days ago an interesting trial trip took place on the Portrush, Bushmills, and Giant's Causeway Electric Tramway. On the day of trial, when a select company was invited to witness the experiment, the distance from Portrush to Dunluce Castle, three and a quarter miles, and mostly uphill, was covered in 20 minutes, the return journey occupying 14 minutes 30 seconds, which gives an average of 13 miles an hour. The trip was regarded as in every sense successful, and great credit redounds to the engineer-in-chief, Mr. W. A. Traill, for the manner in which he has carried forward the undertaking. His Grace the Lord-Lieutenant (Earl Spencer) has promised to attend the ceremony of the opening run right through from Portrush to Bushmills by means of electricity, which is expected to come off about the beginning of next month." As our readers are aware, the line has been constructed on Messrs. Siemens's system.

VIENNA ELECTRICAL EXHIBITION.—From Vienna we learn that, with a view to facilitate the passage of exhibits through the custom house and from the termini to the exhibition, the committee have entrusted this work to the well-known firm of Schenker and Co., of Vienna. This firm have also branch offices at Budapest, Bucharest, London, Munich, Prague, Tetschen on the Elbe, and Trieste, as well as representatives at Antwerp, Hamburg, Mannheim, Paris, and Rotterdam. Messrs. Schenker and Co. will not only aid the passage of exhibits through the custom house, but will also keep an account of the goods exhibited and sent back after the close of the exhibition, look after the storing of the packages during the time of the exhibition, and give every information to exhibitors as to the forwarding of exhibits. The Italian Ministry of Public Works will be represented by its telegraph administration, and the Danish Admiralty will exhibit some new inventions in the department of torpedoes. The Würtemberg Government has appointed Dr. Dielrich, Professor of Electricity in the Stuttgart Polytechnic School, as its representative at the exhibition.

A SCIENTIFIC VETERAN.—Mr. Mattieu Williams writes in the *Gentleman's Magazine* for this month as follows:—"About a year ago I succeeded with some difficulty in obtaining a copy of an old classical treatise, Chevreul's 'Recherches Chimiques sur le Corps Gras d'Origine Animale,' a series of papers published in a collected form in 1823; and I assumed as a matter of course that the author had long since joined his contemporaries—Cavendish, Priestly, Lavoisier, Wollaston, Davy, Dalton, Berzelius, &c. This is by no means the case, for only the other day he read a paper at the Academy of Sciences, in the course of which he said:—'Moreover, gentlemen, the observation is not a new one to me. I had the honour to mention it here, at a meeting of the academy, on the 10th May, 1812.' Here is a chemist who was born before Phlogiston was dead and buried, when the composition of air and water was newly discovered, and who is, therefore, just as old as modern chemistry, and is now vigorous enough in body and brain to still contribute to its advancement. May his venerable voice long continue to be heard from his old, old place in the Academy!"

UNDERGROUND WIRES.—At a meeting of the Committee on Underground Electrical Communication, the formation of which we noticed in a recent leading article (*Electrician*, May 5), held in New York on the 7th instant, it was resolved to form three sub-committees, in order to deal with the subject in as comprehensive and thorough a manner as possible. The first will confine its attention to the electrical and mechanical difficulties that have to be encountered in laying underground wires, and is instructed to examine the inventions now in use, or that may be presented to it. The committee is also to give notice to inventors as to the nature and extent of the requirements of the case, and to state the problem that has to be solved, with the object of concentrating inventive effort in a practical direction. The second sub-committee will deal with the legal side of the question, while the third, known as the sub-committee on business organisation, is to lay before the general committee a plan of organisation for carrying into effect the recommendations of the two other sub-committees, so soon as they shall have been framed and laid before it, and if necessary to form an independent company for the purpose.

AMALGAMATION OF ZINC FOR BATTERIES.—The usual method of amalgamating zinc plates for galvanic batteries consists in freeing them from oxide by means of acid, immersing them in mercury, and rubbing them with a hard brush. This method, however, has the disadvantages of only depositing a superficial coat of mercury upon the zinc, which is soon denuded by the acids of the battery, so as to require speedy renewal. An electrician connected with the French Department of Posts and Telegraphs has invented a new mode of amalgamation, which is reported to give good results. It consists in immersing the zinc, previously to the usual mer-

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cury bath, in a solution of mercurial salt, the composition of which is patented by the inventor. This immersion renders the zinc brittle, its fracture presenting a granular appearance, resembling that of dead silver as it is deposited by electro-metallurgy. This new molecular condition permits of the mercury penetrating the zinc, and filling up its pores, and thus forming an obstacle to attack by the acids of the battery. Besides overcoming the difficulties inherent in the usual method of amalgamating zinc, the new process has the advantage of preventing all useless consumption of the metal when out of circuit, and also of preserving a perfect constancy in the battery until the zinc is completely used up.

Injuring Telephone Wires in London.—The charge against Theodore Torrey, manager of the London and Globe Telephone Company, and two of his workmen, of wilfully and maliciously injuring the wires of the United Telephone Company, was again gone into at the Guildhall on Friday week. The workman, James Reynolds, whose evidence we reported in a note in last week's issue, was cross-examined by the London and Globe Company's solicitor, and stated that he did not know who it was gave the order for tying up the United Company's wires, but it was some one in authority, and resembling Mr. Torrey. The wires were tied up for a little time only, about a quarter or half an hour. An order was given to untie them, but by whom he did not know. As far as he could see there was no necessity for tying them up. James Hopkins, employed by the United Company, gave evidence as to seeing Mr. Torrey and Goodfellow pull the wires together and tie them up. Mr. Torrey, as far as he could see, was giving orders. On another occasion he got up on to the party wall of the Wool Exchange, where the tying up was alleged to have been committed, and was ordered off by Mr. Torrey. The men employed there told him at the time that they had tied the wires up because they were in their way. The derrick on the Wool Exchange carried the Globe Company's wires about a foot higher than those of the United Company. The case was again adjourned.

A Welcome to Mr. J. Aylmer.—Those who visited the Paris Exhibition will agree with us that the success of the English section was in a great measure due to the untiring energy of Mr. Aylmer. He was usually one of the first to be found in the well-known pavilion, and certainly did not leave till the last visitor had gone. It was to Mr. Aylmer that visitors fresh to Paris rushed for information. He it was who facilitated all pecuniary arrangements; indeed, his hand and voice seemed ubiquitous in smoothing away difficulties and rendering pleasant and enjoyable, both from a business and a social point of view, the time spent by visitors at Paris. An opportunity was taken on Tuesday last to invite Mr. Aylmer to dinner by a few of those so deeply indebted to him, to show that his services were appreciated, and that kindly recollection of benefits received was duly impressed upon those with whom he had been brought into contact. The invitations were rather hurried, so that many who might have wished to be present were unable to attend. Dinner was served at the Holborn Restaurant, Mr. R. E. Crompton presiding. Among those present we noticed Mr. Edmunds, Mr. A. J. Frost, Professor G. Forbes, Mr. Kapp, Mr. Muller, Mr. Fahie, Mr. Mackie, Mr. Harold Thomson. The toast of the evening was drunk with enthusiasm, and Mr. Aylmer responded. As may be supposed the conversation of the evening dealt principally with anecdotes and reminiscences of Paris experience, and inquiries as to whom we should meet, and what were the prospects of the forthcoming exhibition at Vienna. Our friend Brooks, with his inexhaustible fund of anecdote, was sadly missed, but there was some satisfaction in observing that with a little more experience the mantle of the prophet will fit well the shoulders of Mr. H. Thomson. After the dinner most of the guests adjourned to see the lighting of the Law Courts, and this was the concluding act of a very pleasant programme.

Electrolytic Experiments.—In the *Journal* of the Chemical Society for May is an abstract of a paper by A. Bartoli and G. Papasogli, on the results of the electrolysis of various solutions, which appeared in the *Gazetta*, Vol. XIII., pp. 37-55. From the experiments they have made the authors draw the following general conclusions:—1. In liquids whose electrolysis is not accompanied by evolution of oxygen at the anode, wood charcoal, retort-carbon, and graphite are not disintegrated, and do not suffer any appreciable loss of weight. 2. On the contrary, in liquids whose electrolysis gives rise to liberation of oxygen at the anode, wood charcoal, retort-carbon, and graphite, employed as positive electrodes, are partly disintegrated and partly oxidised to CO and CO_2 (the relative quantities of which depend upon the strength of the current and the superficial area of the positive carbon) together with other products varying according to the nature of the carbon. 3. Graphite used as positive electrode in these liquids never colours the electrolyte, whereas retort-carbon and charcoal previously purified by the action of chlorine at a high temperature colour the liquid deep black, both in alkaline solutions and in those of certain acids and their salts. 4. Charcoal or retort-carbon employed as positive electrode in solutions of acids or of neutral salts whose electrolysis gives rise to evolution of oxygen at that electrode forms chiefly, or rather almost entirely (besides CO and CO_2), a black substance—called by the authors mellogen—whose composition is represented by the formula $C_{14}H_2O_4$, or a multiple thereof, together with mere traces of benzo-carboxylic acids; whilst in solutions of phosphoric acid, hydrofluoric and potassium antimonate a substance is formed analogous to mellogen in its properties, but containing phosphorus, fluorine, or antimony, according to the electrolyte employed. Graphite, on the other hand, employed as positive electrode in the same liquids, produces—in addition to gaseous CO and CO_2—chiefly graphitic acid $C_{14} H_2 O_3$, or an analogous compound containing phosphorus, fluorine, or antimony, according to the nature of the electrolyte. 5. Wood charcoal and retort-carbon, as well as graphite, used as positive electrode in alkaline electrolytes, yield mellic acid $C_{12} H_6 O_{12}$, pyromellic acid $C_{10} H_6 O_8$, hydromellic acid $C_{12} H_{12} O_{12}$, and another body, which is either hydropyromellic acid, $C_{10} H_{10} O_8$, or an acid isomeric therewith.

Legal.—The Telephone Suit.—The case of the United Telephone Company *v.* the London and Globe Telephone and Maintenance Company came before Mr. Justice Pearson on Tuesday last. Mr. Cozens Hardy, Q.C., and Mr. Moulton moved on behalf of the plaintiffs for an injunction to restrain the defendants, their servants, agents, and workmen, from interfering with the telegraph or telephone wires of the plaintiffs, or the supports thereof, or any instruments or apparatus connected therewith, and they asked for an order directing the defendants forthwith to take down or remove any posts or wires or other erections placed or erected by them so as to interfere with any such wires, supports, or apparatus. From the affidavits in support of the plaintiffs' case it appeared that the plaintiffs' company was formed for the purpose of setting up a communication between the houses and offices of the subscribers, so that by ringing a bell fixed at the chief office any subscriber could be put in

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communication with another, and after they had finished the interchange of messages the communication was broken off. The plaintiffs stated that they had as many as 2,760 subscribers, and the average daily number of messages amounted to 38,000. For the purpose of setting up their wires and poles they had obtained the sanction of the owners of houses and property in their district. It was then stated that the defendants' company was formed in August of last year for the purpose of carrying on a business similar to that of the plaintiffs, and they alleged that in erecting their poles and passing along their wires they had seriously interfered with the wires of the plaintiffs. In some cases they had allowed their wires, through which no messages were at present passed, to rest upon those of the plaintiffs. In other cases they had interfered by means of their poles, and in many instances the defendants' wires were placed so close to those of the plaintiffs that a slight wind, or even change of atmosphere, caused the wires to join together, and to pass the electric current through the wrong wires; but the worst instances of interference were where the defendants had actually coupled together the plaintiffs' wires by means of a band, seventeen in one place, and nineteen in another. The effect of this interference with the plaintiffs' wires was sometimes to cause the bells of subscribers to be rung at the wrong time and place, and sometimes all the bells were set ringing at once, to the great annoyance and injury of the subscribers generally.—Mr. Hemming, Q.C., and Mr. Beale, who appeared for the defendants, asked for time to answer the plaintiffs' affidavits, copies of which had only been furnished to them on the previous day (Monday). They were instructed to say that an answer could be given to all the allegations made by the plaintiffs, but this would necessitate the examination and cross-examination of witnesses, and it would be impossible to prepare the defence in less than a fortnight or three weeks.—Mr. Cozens Hardy, Q.C., submitted that if the case was ordered to stand over for so long a time the defendants ought to be put upon an undertaking either to alter their poles and wires, so as to avoid any interference with the plaintiffs' wires, or they should allow the plaintiffs to do the work themselves, and it was pointed out that there would be no difficulty in doing this at once. If this was not done the injury to the plaintiffs' business might be continued for three weeks or more until the case could be brought on for hearing.—As the defendants did not accede to the plaintiffs' proposal, Mr. Justice Pearson said, under these circumstances, he must treat this as an *ex parte* application, and he should grant an injunction in the terms of the motion to restrain the defendants from interfering with or continuing to interfere with the telegraph or telephone wires of the plaintiffs. The hearing of the motion would then stand over till Thursday fortnight, and the defendants might have liberty to bring on the motion at an earlier period if they preferred to do so.

Electric Light in Liverpool.—A successful installation of six Pilsen dynamos and fifty Pilsen arc lamps has recently been completed at Messrs. Lewis's establishment, Ranelagh-street, Liverpool. This is probably one of the largest installations of arc lights that has yet been made in one building. The work was entrusted to Messrs. Woodhouse and Rawson, electric light engineers, of 11, Queen Victoria-street, E.C., and has given every satisfaction. We may mention that Messrs. Lewis are not by any means new to electric lighting, having for the last two or three years made various experiments with the different systems, and their present house in Manchester has been for the last year or two chiefly lit by Siemens arc lamps. The building in Ranelagh-street consists chiefly of two portions, the old place of business, and a new one, which was opened shortly before Christmas. The latter is a large edifice, consisting of seven stories, basement and sub-basement. The intention was to light up the whole of the building with arc lamps; but, as some of the floors are not occupied, fifteen lights have been temporarily put up in the old building. Here the lights are on the ground floor; in the new building they are distributed over four floors, and over the pavement on the outside of the building. In the basement, which formerly was unbearable when gas was used, four lights have been placed. On the ground floor there are seventeen, including a large 4,000 candle-power lamp in the doorway, which throws a flood of light on to the side show windows and across the street. On the first floor there are six lamps, and in a louvre at the top of the building, which is called the lantern, nine. The effect of these latter, the light from which comes through stained glass sides, is very fine, and can be seen from a considerable distance. Half the sub-basement is at present set apart for engine and machine room. The engine and boiler were supplied by Messrs. Marshall, Sons, and Co. The boiler is of the locomotive type, in which steam can be raised in a very short time to a working pressure of 60lb. The engine is 35 h.-p. nominal, high-pressure horizontal 18in. cylinder, 3ft. stroke, with automatic expansion valve, worked from the governor. It runs at 70 revolutions per minute, and is capable of running about 100 2,000 candle-power lamps. The power is communicated from a 10ft. fly wheel by a treble leather belt, 66ft. long, 20in. broad, to a 4in. steel countershaft, and thence to the dynamos by 6in. belts, all double copper sewn. The dynamos and lamps were made by the Pilsen-Joel and General Electric Light Company. The machines, like those of the Schuckert class, are of the ring armature type, similar to the Gramme, with the exception that the induction of the coils takes place on the lateral vertical faces of the armature, whereas in the Gramme the induction takes place on the horizontal periphery. The machines are wound in series, giving an E.M.F. of about 42 volts per lamp, with a current of about eight amperes. The cables used are seven strands of copper, No. 16 B.W.G., heavily insulated. Above each machine is a German silver resistance board of about 4 ohms, by means of which the external circuit is regulated when required. The leads and returns are taken from each machine to a switch board for the purpose of facilitating change of circuits, as it is often required to run different groups of lamps independent of the circuits upon which they may happen to be. This grouping is materially helped by means of switches arranged in convenient parts of the building. From the switch board the cables pass into an air-shaft, which, running to the top of the building, is used for ventilating the different rooms by means of channels between the ceiling and floor. These channels, which are covered by movable boards screwed down with iron bearers and lugs let into the rafters, carry the cables after they leave the air shaft. This arrangement avoids the appearance of leads on walls and ceilings, a ready access being had to the wires, which are brought down to the lamps through holes in ornamental work, in the centre of which the lamps are hung. The cables for the old building pass right up to the top of the ventilating shaft, and are then carried overhead from roof to roof, and down to the ground-floor to a switch, which is so arranged that eight lights may be run off the 7-light machine during the early part of the afternoon, until the other four are required, when the whole are switched on the 12-light machine from the switch board in the engine room.

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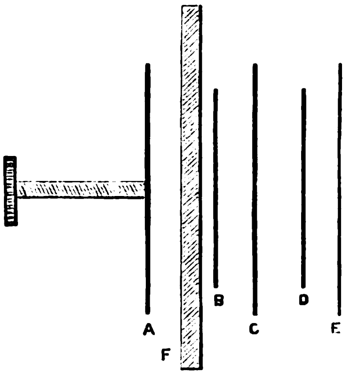
ELEMENTARY ELECTRICITY.—X.

(CONTINUED FROM PAGE 11.)

Gordon's Method of Measuring Specific Inductive Capacity continued.

On introducing between A and B a plate, F, of some dielectric whose specific inductive capacity was greater than unity after the balance had been adjusted, the induction of A upon B became greater than that of E upon D, and to restore the balance it was necessary to remove the plate A to a greater distance from B. By measuring the distance through which the plate was moved, the specific inductive capacity of the dielectric could be determined, for the thickness of the equivalent layer of air could be calculated. A motion of the plate A through ·001in. produced a very perceptible movement in the spot of light reflected from the electrometer mirror. Gordon's experiments gave results varying from 3·108 to 3·838 for different varieties of flint glass, 1·9936 for paraffin, 2·22 for black india rubber, 2·462 for gutta percha, and 2·547 for Chatterton's compound. It is of great importance to obtain accurate determinations of the specific inductive capacities of the insulators employed in the construction of submarine cables, as a high specific



inductive capacity for the insulator means a great electrostatic capacity for the cable, and a corresponding reduction in the speed of signalling.

The fact that in Gordon's apparatus the distances between the plates were not very small in comparison with their diameters introduced great difficulties into the calculations.

Def. The *electric intensity* at a point, or, as it is sometimes called, the *electromotive force at a point*, is the number of units of force which would be experienced by a unit of electricity placed at that point. It has been called electric intensity from the analogy of magnetism and gravitation.

Def. A line of force is a line which, at every point, is in the direction of the resultant force at that point.

The direction of a curved line at any point is the direction of the tangent to the curve at that point.

If a number of electrified bodies be immersed in an insulating liquid, such as paraffin oil, the directions of the lines of force can be exhibited by throwing into the liquid some fine cotton or linen threads, when the conducting threads will take up the directions of the lines of force between the electrified bodies.

Faraday conceived an electric field permeated by lines of force which always proceed from positively to negatively electrified surfaces, taking their origin whenever there is a positive charge and proceeding to an infinite distance unless they meet with a negatively electrified surface. Faraday not only regarded the lines of force as indicating the direction of the resultant force at every point, but he supposed the number of lines of force proceeding from any charged body to be equal to the numerical value of its charge. Maxwell pointed out the analogy between Faraday's lines of force and the "*stream lines*," or lines of flow, in a fluid, and showed that, in virtue of the fundamental law of electrical action, *i.e.*, the law of inverse squares, if lines of force be drawn according to Faraday's system, the number of lines passing through unit area of any surface will be proportional to the force at right angles to that surface, and this will be true wherever the surface may be situated in the electric field.

In hydro-dynamics stream lines are the paths pursued by individual particles of the fluid. In the case of irrotational steady motion these stream lines do not cut themselves, for a particle never returns to the same point, and they do not cut one another, for the fluid being supposed continuous each stream line is completely occupied by its own line of particles, and two particles cannot be at the same point at once. The points at which fluid enters the stream under consideration are called sources; the points at which it leaves the stream are sinks. Stream lines come into existence at sources and disappear at sinks, but are continuous everywhere else; for a particle must preserve a continuous existence from the time that it enters the stream until it disappears. In all cases in which it is a material fluid that is under consideration, the particles must, of course, have come from somewhere when they appear at the source, and must be going somewhere when they disappear at the sink, and it would be possible to trace the stream lines backwards beyond the sources, and forwards beyond the sinks; but if we do not consider the particles until they appear at the sources, and cease to consider them as soon as they reach the sinks, their behaviour is, to us, the same as if they sprang into existence at the source, and went out of existence altogether at the sink. The steady flow of heat through conductors resembles the flow of a liquid, but in this case the heat may really be produced, from some other form of energy, at the source, and may cease to exist, being converted into some other form of energy, at the sink.

If a closed curve be drawn within the substance of a liquid which possesses a steady motion, and through every point in the curve a line of flow be drawn, a tubular surface will be generated. This is called a tube of flow, and the quantity of liquid which passes every section of the tube in a second will be the same. If this quantity be the unit of volume we may call the tube a unit tube of flow. If the whole transverse section of a stream be supposed divided into small areas, across each of which the unit quantity of liquid flows in a second, and if lines of flow be drawn through every point in the boundary lines of these areas, the whole volume of the liquid will be cut up into tubes such that unit volume of liquid passes every section of every tube in a second, that is, into a number of unit tubes of flow. These tubes will exactly fit one another, filling up the whole stream, and never cutting one another; but if there be a source anywhere within the liquid, a number of new tubes will there originate equal to the number of units of volume of liquid sent into the stream in a second, while at a sink a corresponding number of tubes of flow will converge and disappear.

Maxwell showed that precisely the same theorems are true respecting Faraday's lines of force. In place of the volume of liquid flowing across any section of the tube we must substitute the amount of electricity displaced across a thin conducting surface placed at right angles to the tube, and which may be called the induction across the tube. Then, if any electrified area be cut up into contiguous portions, each possessing a unit of positive electricity, and if lines of force be drawn through every point in the boundary lines of these portions, a series of unit tubes of force will be formed exactly filling space without leaving gaps between or intersecting one another. Maxwell showed that the amount of induction measured by the quantity of electricity displaced across a thin conducting surface cutting the tube orthogonally across every section of every tube will be unity, and this is a consequence of the law of inverse squares. At every positively electrified surface tubes of force, in number equal to the charge upon the surface, will spring into existence, and at every negatively electrified surface tubes will disappear equal in number to the measure of the negative charge, so that every positively electrified surface behaves like a source, and every negatively electrified surface like a sink. Everywhere else in the field the lines of force preserved a continuous existence.

Suppose a unit of electricity to be placed within a sphere of unit radius, the electric intensity at every point of the

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surface of the sphere will be unity. The area of the sphere will be 4π square centimetres, and the product of the area and the electric intensity at any point will, for the whole sphere, be 4π. It is now usual to regard as a unit tube of force a tube such that the area of any section of the tube multiplied by the electric intensity at the section may be unity, the product of any area into the electric intensity in the direction normal to the area is now called the electric induction through the area (*i.e.*, the surface integral of the normal force). The induction through the surface of the unit sphere above mentioned will, on this reckoning, amount to 4π, and its surface should be penetrated by 4π unit tubes of force or of induction. Hence, according to the modern system, every unit of electricity gives birth to 4π unit tubes of force, and from the surface of a conductor charged with q units of electricity $4\pi q$ unit tubes of force will originate and proceed to infinity unless they meet with a negatively charged surface.

If we suppose the unit sphere, having a unit charge at its centre, to be insulated, but made of gold leaf, there will be induced upon its inner surface a unit charge of negative electricity, while a unit charge of positive electricity will be uniformly distributed over its entire surface. These charges being indefinitely near together will neutralise one another's actions everywhere except within the substance of the gold, and thus the force a little way outside the sphere will be the same as before. But this force will be that due simply to the charge on the outside of the sphere, for all the lines of force proceeding from the central charge will be stopped by the negative charge on the interior surface of the sphere. Also the number of units of electricity on each unit area of the outside of the sphere, *i.e.*, the surface density of the electricity on the outside of the sphere, is $\frac{1}{4\pi}$. Since this produces unit force on a unit of electricity in its immediate neighbourhood, it follows that the electric intensity just outside a surface charged with electricity of density ρ is $4\pi\rho$. This result is of importance in connection with the attracted disc electrometers, which will shortly be mentioned.

Maxwell showed that the dielectric will be in equilibrium if we suppose that there is a tension along the lines of force, accompanied by an equal pressure in every direction at right angles to these lines, and that such a distribution of stress will account for all observed electrostatic phenomena. Thus, if lines of force pass from one body to another, there will be an attraction between the bodies represented by the resultant of the tensions along these lines; and we know that such an attraction exists, for the bodies must be electrified oppositely. Again, if two bodies, placed near together, are both positively electrified, lines of force will proceed from each, but the pressure at right angles to the lines causes them to appear to repel one another, and, instead of there being a tension tending to draw the bodies together, there will be a pressure tending to separate them more widely, as if the bodies actually repelled one another. By this hypothesis of stress in a medium, the necessity of assuming a direct action at a distance between the electrified bodies is obviated. When we speak of magnetic lines of force we shall give some illustrations which will apply equally well to electrified systems.

If tubes of force are drawn, in accordance with the system explained above, so that the product of the sectional area of any tube and the electric intensity in the neighbourhood is always unity, such a system of tubes will completely indicate the direction and magnitude of the force acting on a unit of electricity placed anywhere in the field, for the axes of the tubes will be everywhere in the direction of the resultant force, and the sectional area of the tubes will be inversely proportional to the force. Thus the tubes will widen whenever they reach places where the force is weak, and contract in places where the force is strong, just as the stream lines in a river widen out when the river widens and the velocity diminishes, but contract when the bed of the river is narrowed and the velocity of the stream increases, as in approaching rapids.

Since the resultant force is everywhere normal to the equipotential surfaces, it follows that if the tubes of force and equipotential surfaces be drawn for any system the former will be cut by the latter at right angles, and the electric field will be divided into rectangular blocks or cells. Wherever the force is strong the tubes will be narrow, and the equipotential surfaces near together, so that, for both reasons, the cells will be small. Where the force is weak the equipotential surfaces will be far apart, and the tubes wide. If the tubes are drawn according to the system of Faraday, so that the number of tubes proceeding from the surface of a charged body is equal to the number of units of electricity upon the body, and if the equipotential surfaces are drawn for each unit difference of potential, then, as shown by Maxwell, the number of cells into which the electric field is divided will be equal to twice the number of ergs of energy possessed by the system, and each cell will contain half a unit of energy. If the tubes are drawn so that the number proceeding from a charged body is equal to 4π times the measure of its charge, then each cell will contain $\frac{1}{8\pi}$ of the units of energy.

The fact that the energy is proportional to the number of cells suggests the idea that the cells are themselves the receptacles of the energy, that is, that the energy of an electrified system resides in the dielectric. This at once points to a condition of elastic strain existing in the dielectric which is thus rendered capable of being the vehicle of electric stress, and the cause of the apparent attraction or repulsion between electrified bodies as explained above.

Dr. Kerr succeeded in showing that glass and other dielectrics, when exposed to the action of electric forces, are thrown into a state of mechanical strain by transmitting a beam of polarised light through the dielectric at right angles to the lines of electric force. When the Nicol prisms of the polariscope were crossed, and the field dark to commence with, the light reappeared as soon as the electromotive force attained a certain intensity.

Röntgen repeated Dr. Kerr's experiments, employing bisulphide of carbon as the dielectric, and obtained some very beautiful results.

If two parallel plates are placed near to one another but maintained at different potentials, lines of force will proceed from the plate at higher potential to that at lower potential, and, except very near the edges of the plates, these lines of force will be parallel to one another and perpendicular to the plates, for there is no reason why the lines should bend in one direction rather than another. Hence the electric force will be uniform at all points between the plates which are not very near the edges, and the numerical value of the force will be equal to the difference of potential between the plates divided by the distance between them. At points very near the edges of the plates the lines of force will be curved outwards, their lengths will consequently be increased, as well as the distances between them, and the intensity of the force will be correspondingly less; but its exact value is very difficult to calculate.

Sir William Thomson took advantage of the uniformity of the force at all points between two parallel plates, which are not very near their edges, in the construction of the various forms of trap-door electrometer. The essential feature of these electrometers is a disc, or trap-door of metal, which very nearly fits a hole made in the middle of a large metal plate, which is called the "guard-ring." Near this plate or guard-ring is a parallel plate of metal, whose distance from the guard-ring can be altered and measured by means of a screw with a divided circle upon its head. The trap-door is in metallic communication with the guard-ring and is supported, in the absolute electrometer, by springs, and in the portable electrometer by the torsion of a wire, in such a way that its position of equilibrium is a little beyond the plane of the guard-ring. When a difference of potential is produced between the guard-ring and the attracting disc the trap-door is drawn towards the disc with a force depending on the distance between the plates and on their difference of potential. The distance between the plates is then regulated by the screw until the trap-door is drawn into the plane of the guard-ring in opposition to the action of the springs or wire. The distance

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between the plates is then proportional to the difference of potential. The idiostatic gauge is similar to the portable electrometer, except that the distance between the plates is fixed, the object of the instrument being to determine when the difference of potential attains a fixed standard.

If V denote the difference of potential between the discs of an attracted disc electrometer, and d the distance between them, the electric intensity or force which would act on unit of electricity at any point between the discs will be $\frac{V}{d}$, since V units of work are done on the unit charge in passing over the distance d. Hence the force just beyond the surface of one of the discs is $\frac{V}{d}$. But if the surface density of the electricity upon the disc be denoted by ρ the force must be $4\pi\rho$. Therefore,

$$4\pi\rho = \frac{V}{d},$$

or

$$\rho = \frac{V}{4\pi d}.$$

If A denote the area of the trap-door, the whole charge upon it will be $\frac{AV}{4\pi d}$. To find the force with which the trap-door is attracted to the lower disc we must observe that of the force exerted upon a small charged body placed between the discs one half is due to the action of the upper disc and one half to that of the lower disc, since the discs are equally and oppositely charged and of very large dimensions compared with the distance between them. Hence the attraction of the attracting disc on every unit of electricity upon the trap-door is $\frac{V}{2d}$, and the whole attraction, P, on the trap-door will be equal to the product of this quantity and the charge of the trap-door. Therefore,

$$P = \frac{AV}{4\pi d} \cdot \frac{V}{2d} = \frac{AV^2}{8\pi d^2}.$$

Hence,

$$V = d\sqrt{\frac{8\pi P}{A}},$$

that is, for the same instrument the difference of potential is proportional to the distance between the plates if the attraction P between them is constant.

When we come to consider magnetic lines of force we shall give illustrations of the behaviour of a mass of iron in a magnetic field. The presence of the iron causes the lines of force to be drawn aside from their original directions, so that a large number of lines converge upon and pass through the iron, diverging again from the other side. This effect can be exhibited at once by placing a piece of iron on a card near to a magnet, and then scattering iron filings over the card, when the lines of force depicted by the filings will be seen to converge upon one side of the iron and reappear at the other side. The same action takes place to a greater or less extent when any body whose magnetic inductive capacity or magnetic permeability is greater than that of the surrounding medium is placed in a magnetic field.

A precisely similar phenomenon occurs when a non-conducting body whose specific inductive capacity is greater than that of the surrounding dielectric is introduced into an electric field. The lines of force are drawn aside so that more lines of force pass through the body than originally passed through the space occupied by the body before it was introduced. Thus lines of force will converge upon one side of the body, pass through it, and diverge from the other side. The lines of force become thus concentrated in the body to an extent depending on its specific inductive capacity.

If the body were replaced by a conductor the latter would be electrified by induction negatively on the one side and positively on the other. The lines of force would converge upon the negatively electrified portion and diverge from the positively electrified portion. The effect upon the lines of force in the field is similar to that of the dielectric of high specific inductive capacity, only more marked. As far as its action outside its own substance is concerned, the conductor behaves like a dielectric of infinite specific inductive capacity, while a dielectric of greater specific inductive capacity than the rest of the field behaves like a conductor, but to a less extent; in fact, it behaves as if it had a surface electrification, negative on the one side and positive on the other, but of less density than that which would be induced on a conductor of the same dimensions occupying the same position. Hence the dielectric, like a conductor, will tend to move towards the strongest part of the field, just as a piece of iron tends to move up to the pole of a magnet, and for a precisely similar reason. This is the principle of Boltzmann's method (described last week) of measuring the specific inductive capacities of balls of sulphur ond other dielectrics by the attraction between the balls, and a small charged conductor.

This attraction between a dielectric of great specific inductive capacity and a charged conductor depending on the tension along the lines of force admits of a simple, though only a partial mechanical illustration. Suppose a number of stretched elastic strings to be diverging from a small body, and attached to the walls of the room. Now let a ring be placed so that several of the strings are compelled to pass through it, and are thus drawn much closer together than they would otherwise have been. Between the body from which the strings are diverging and the ring the strings will diverge less than before; but after passing through the ring they will take a turn and diverge more rapidly than before, so as to reach their points of attachment on the walls by as short a path as possible. The effect of the tension of the strings upon the ring will be to force it along the strings towards the body from which the strings are diverging, since this will enable the strings passing through the ring to contract along their length. Thus the ring will be urged towards that portion of space where the strings are naturally closest together. Replace the strings by lines of electric force, the body from which they originate by a positively charged body, the walls of the room to which the remote ends of the strings are attached by a negatively electrified surface forming the boundary of the electric field, and the ring through which some of the strings are drawn by a body of specific inductive capacity greater than the rest of the field, and we have a partial representation of the electrical problem; but we must remember that in the electrical case the lines which correspond to the strings are not only themselves in a state of tension, but behave as though they repelled each other.

CORRESPONDENCE.

ELECTRIC LIGHT FOR NOTHING.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: There may be, and I take it there is, much of commendable self in our various branches of industry—a sort of weakness to be paid for our work; yet we appear to be approaching more philanthropic principles, demonstrating a pleasing fact, at least to the general public, that there exists in some minds a strong desire to work for nothing, if I may be allowed to judge by a statement in a local paper now under my eye.

This report explains that a local corporate body was desirous of lighting its Town Hall with the electric process; but here is the remarkable feature, that whilst a certain electric company had its honourable estimate for lighting under favourable discussion, a member of the council reminded the committee that "they had an offer from an electric lighting company, close to their own doors, to try the light in the borough free of cost."

Now, sir, I can quite understand that a public company, in its initiating state, before the shares are subscribed for, may light up prominent places gratuitously, and lead an innocent public to suppose the concern to be not only sound, but profitably engaged, and thus secure a good subscription list and much moneys; but why a company that has secured the only object which seems to be the final effort and the only one of most—a large subscribed capital—should offer to light up a large public building for nothing,

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like the dog in the manger, against the more honest offer of another company, can be only explained by that unscrupulous principle of employing a share capital for purposes ruinous to the general body of proprietors.

Your columns have disclosed within the past few weeks so many cases of maladministration in the management of the funds of public electric companies, so much wide-spread ruin to many an investor, that it is no surprise to me that the system has so greatly suffered in character, and that so many companies are in a condition of semi-liquidation.

There is a great and profitable future for the electric system, but it will not be attained under the present one-sided system of management. W. M.

MICROPHONIC CONTACTS.

TO THE EDITOR OF THE ELECTRICIAN.

Sir: Many of the phenomenas which are reported by experimenters on loose carbon contacts, notably those in the very interesting observations by Mr. Stroh, are, in my opinion, clearly due to carbon dust on the surface of the solid pieces. It is important that the contact surfaces should be permanent, and very hard and homogeneous, and I beg to suggest that the carbons used for these experiments be carefully washed in clear water, and afterwards dried. Even an apparent smooth surface brought about by polishing is not reliable, and should be tested by washing the surface under water with the finger, or a piece of cloth.

To definitely settle the loose contact transmission, the apparatus ought not only be free of carbon dust, but the current employed ought to be so low and the carbons so hard that no burning can take place. The action by means of detached carbon particles—an arc—is a special phenomenon, and different from a so-called "contact" transmission, and it has ever been the aim of those who first conceived the "contact" principle in telephony to confine themselves to that principle. The time is near at hand when it will be clearly proved that the so-called microphone is merely a contact transmitter of defective mechanical construction, that its name is misapplied, and that the apparent increase in sound is partly due to the scraping of the parts in contact, partly to the fact that the telephone is pressed closely to the ear, and excludes all other sounds. The many theories brought up to explain the microphone, viz., "heat," "arc," "variation of contact area," "number of molecules in contact," "compression of carbon"— all these lack positive proofs, are obscure and confounding, and some have been shown to be wrong; but somehow or other there seems to be in some quarters too much pride to confess that such theories *are* wrong, and the "practical," though less "scientific" workers, who, through laborious experiments had long arrived at the correctness of their own now acknowledged theory, are silently ignored.—Yours, &c.,

E. Berliner,
Chief Inspector American Bell Telephone Company.
Boston, May 9, 1883.

INFORMATION WANTED.

TO THE EDITOR OF THE ELECTRICIAN.

Sir: Will your esteemed correspondent and contributor, J. T. Sprague, have the goodness to tell me how to construct a magnetic belt or magneticon, &c. I am very much in want of one, as I suffer very much from rheumatism, and the price charged for belt or body bandage, &c., is so high it is not within my reach at present to get one. Any information from any of your correspondents will oblige.—Yours, &c.,

May 18, 1883. Neuralgia.

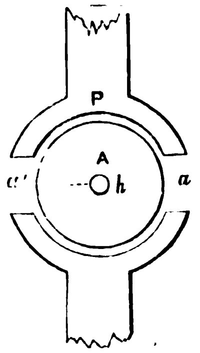
[We insert "Neuralgia's" letter, although we are afraid he will not find Mr. Sprague very ready to tell him how to construct "a magnetic belt or magneticon," seeing that Mr. Sprague views, and justly so, such appliances with but scant favour. "Neuralgia" would, we think, do better in consulting a good doctor.—Ed. *E.*]

THE GRAMME RING.

TO THE EDITOR OF THE ELECTRICIAN.

Sir: Your correspondents, Mr. Mordey and Mr. Sayers, I have to thank for their courteous criticism of my somewhat imperfect statement concerning the action of the inner wire in the Gramme ring. I did not say all that was in my mind, but I drew a conclusion from a partial statement, which conclusion really came about from a much more extended consideration. I ought perhaps in strictly logical sequence to amend my proposition, and to say that the inner wires of the Gramme ring have no deleterious action on the system; but that would not be quite as far as I would go. With one or two remarks on the proposed experiments I will pass to the description of my own trials, which I hope your correspondents will accept in lieu of more formal argument. The experiment proposed by Mr. Mordey hardly covers the ground. There are clearly two actions (if not more) that may occur in the Gramme ring, (1) the constant approach and retrocession of an element of the ring into and from the magnetic field, (2) the cutting of lines of force by the wires of the ring. Now, my contention is that from these two causes of E.M.F. in the coils of the ring the first is by so far the greater that *in practice* the second may be neglected. Considered apart, I have no doubt that the experiment proposed by Mr. Mordey would be strongly in favour of (2), and that the lines of force cut *are* greater on the one side of the ring than the other, but the greatest E.M.F. is undoubtedly due to (1), or the determination of the lines of force into the iron of the ring considered as a circular electro-magnet.

My attention was first drawn to this by the following experiment, made for another purpose, viz., that of ascertaining the best size of pole-piece. I took a Gramme ring, A, and surrounded it with the long horns of a heavy pole-piece, P.



Between the ends of the horns *aa* there was a heavy discharge of lines of magnetic force. I maintained in all the following alterations the strength or intensity of the magnetic pole P *constant* by changing the amount of current passed around the coils on P, measured by Du Moncel's method of approaching a solenoid to the pole at constant speed. The speed of revolution of the ring A was also kept as constant as possible. The horns were then shortened and the E.M.F. increased. At about *h* I expected the E.M.F. to remain constant, but it increased until no horn remained, and the pole-piece was of same size as core of magnet. [I want it understood that the magnets were separately excited, and that the increased magnetic intensity consequent upon decreasing the volume of the pole-piece was compensated for, as measured as described, by reducing the current.] Whence it appeared to me that very little E.M.F. could be due to cutting of lines of force between pole-piece and ring, and that this must depend on the strength of the pole induced in the ring.

I afterwards found that the section of the electro-magnet should be twice the section of the ring to give, experimentally, the best results as regards E.M.F., that is, with a Gramme ring; with the Pacinnotti ring the results are not quite the same.

Subsequently I tried to verify these results by winding a ring the width of which was half its diameter, first as a drum, then as a Gramme ring. In the first case, where the winding was as a drum, I got an E.M.F., equivalent, at the

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speed, to the length of wire passing over the width of the drum. [I need scarcely point out that the E.M.F. is independent of resistance.] I then wound the wire as in a Gramme ring, and got immediately *nearly* twice the E.M.F.; had this inner wire been inert I should have had no increase.

Next I dismounted a Schuckert machine, and causing the magnets to be set up on one side only of the ring, I revolved the ring at constant speed, and put current on to the magnets till there was no increase of E.M.F. I then caused the magnets on the other side to be set up and added; the increase of E.M.F. was about 2 to 3 per cent. Evidently the cutting of lines of force, although in this case not so conclusively negative in this last result, cannot be said to be the chief cause of the current in the Gramme ring, *in practice*.—Yours, &c., PAGET HIGGS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In my letter, published on page 16 of your last week's issue, second column, line 13, the word *course* should read *cause*.—Yours, &c., W. B. SAYERS.

May 19, 1883.

TESTING LIGHTNING CONDUCTORS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Your correspondent "Good Earth," in your impression of 21st April last, asks a very important question regarding the earth resistance of lightning conductors, which I hoped would be answered before this by some one with large experience in that branch of electrical testing. I trust some one will yet be disposed to do so for the benefit of many of your readers who are interested in the subject. Meantime I give you some results I obtained last year in testing the conductors of three factory chimneys, which I trust will prove useful.

I found that No. 1 on several trials had a resistance of 42·9 ohms. Thinking this much too high, I got the earth end lifted. It consisted of only 6ft. of the conductor with the end untwisted about 6in., buried 3ft. below the surface in dry soil at the base of the chimney. In order to improve the "earth," I had a copper band, of greater area than the conductor, fastened round an iron water pipe 15in. diameter, which passed near the chimney. The band was drawn up tight with a bolt, and common solder sweated in between the band and pipe, over an area of some square inches. The conductor was then laced through holes in one end of the band, which projected for the purpose, and carefully soldered. Tests now showed that the resistance had fallen to about ·6 ohm. It varied between ·46 and ·75. I have tested this conductor again to-day, and find the resistance to be ·26 ohm for "earth."

No. 2 conductor had 4·37 ohms resistance. Compared with No. 1 this was a poor "earth." It was therefore lifted, and found to consist of about 16ft. of the $\frac{1}{2}$in. copper rope buried in dry soil. It was "re-earthed" by splicing and soldering to one end of another piece of conductor, which was led about 40ft. distant to a deep well, into which the other end was dropped about 7ft. This alteration had the effect of reducing the resistance to ·38 and ·42 ohm. Thinking the "earth" might be still further improved by soldering the hose end to a 5in. iron pipe in the well, the latter having a very large surface contact, it was connected by copper band in the same manner as No. 1, but the resistance became somewhat greater, viz., ·6—·7 ohm. The bare conductor submerged in water seems to be the best "earth."

No. 3 was a new conductor just erected. It consisted of a copper rope $\frac{5}{8}$in. diameter in two pieces. The earth piece was soldered by means of a copper band, as before, to an iron pipe 15in. diameter, and 20ft. below the surface. The earth resistance measured in this piece alone was ·66 to 1·25 ohm. It was then spliced to the conductor on the chimney, and the joint well soldered. On again testing so that the splice was included in the circuit the resistance was ·74 to ·86 ohm.

As great care was taken in making these "earths," I concluded they were the best possible. I am now glad to find a confirmation of this in their close agreement with that o the conductor recently erected on the General Assembly Hall at Edinburgh, where the earth resistance seems to have been about ·7 ohm.

Your report of the tests of this conductor is interesting as being the first instance I have met with in which a figure is given for a *good* earth resistance. Surely this point is not intentionally withheld. Yet I have looked at text books on electricity and electrical testing and find no mention of it. I have read Anderson's book on "Lightning Conductors," Wilson's little book on "Factory Chimneys and Conductors," as well as the "Report of the Lightning Rod Committee" appointed to collect information of this kind, and although all of these authorities speak of the importance of making conductors terminate in "good earth," of having them periodically tested, and even figure a special instrument for testing, not one of them give the slightest hint as to what "good earth" is!—Yours, &c., T. L. P.

Greenock, 22nd May, 1883.

TELEPHONES.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: The observations I made on metal microphones of the hammer and anvil type were meant to apply generally, and not to Mr. Theiler's instruments in particular. I should be sorry to disparage his or any other instrument intentionally, and I am pleased to find that he has succeeded in overcoming the "stiction" on which too much stress has been laid since Mr. Bidwell's experiments and inference. Being an advocate for the possibilities of metal microphones, I am not disposed to question Mr. Theiler's success, though *a priori* I had grave doubts about it, for the reasons formerly given. By wasting of the "points," I, of course, meant the contact points or surfaces, which every metal microphone must have.—Yours, &c., J. MUNRO.

DOUBLE WOUND DYNAMOS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Mr. Ernst Richter, in your last issue, mentions that the double winding of dynamo-machine magnets has been described by Sinsteden in 1871. Will any of your readers kindly refer me to the description of this double winding on *separate* cores? This arrangement was patented by me in 1881, and in work early in that year, and I really fail to find that Sinsteden does more than merely indicate a double winding on the *same* core, an arrangement that, as shown by the able diagrams of Mr. Richter, does not give nearly so perfect regulation, and besides has several disadvantages as regards induction.—Yours, &c., PAGET HIGGS.

THE LIGHTING OF NOTTINGHAM.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Will you kindly correct the following error which appeared in my letter to you of the 17th of May.

For 4d. per horse-power per hour it should be ·4 or $\frac{4}{10}$d. per horse-power per hour.—Yours, &c.,

R. E. CROMPTON.

PRACTICAL TELEPHONY.

(CONTINUED FROM PAGE 19.)

GALVANOMETERS.—The kind most in use are known as detectors, in which the needle hangs vertically, the lower end being weighted. As, however, it is at times more convenient to use the instrument on its back, dial upwards, it is preferable that the needle be kept to zero by a small directing magnet, instead of the end of the needle being weighted. Its position is then of no moment, and the magnet may also be removed, whereby the sensitiveness of the instrument is much increased. When the magnet is removed the instrument must be turned till the needle points to zero.

It is also an advantage to have the scale on the lower half of the dial instead of the upper, where it is frequently hidden by the

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brass rim that holds the glass, when used standing on the ground. These instruments should be wound for quantity and intensity, as they are usually termed, the quantity or short coil wire consisting of a single layer of thick wire, and having a very low resistance, the intensity or long coil wire being very fine, and having a resistance of 150 to 200 ohms.

It much increases the utility of this instrument if the fine wire, or intensity coils, are provided with a shunt having one-ninth of their resistance, so that only one-tenth of the current passes the intensity coils when the shunt is in circuit. A small switch must be provided to put the shunt in or out of circuit. Detectors are now made having these improvements.

In addition to a supply of detectors, each office should have a horizontal astatic galvanometer to use with the Wheatstone bridge coils, this form being much more sensitive than the detector, the needles being carefully balanced, and the holes jewelled to reduce friction.

As its needle is kept in position by the earth's magnetism, the instrument must be turned so as to bring the needle to zero.

A small magnet is usually supplied with these instruments, which can be laid on the table some distance away, either to reduce or increase the sensitiveness of the instrument, the reduction or increase depending whether the north pole of the magnet is attracting, or repelling, the internal needle; to increase the sensitiveness the position of the magnet should be such, that the needle just returns to zero after having been deflected, and yet if it be placed the least closer, it drives or repels the needle from zero.

There are numerous other forms of galvanometers, but the above two instruments are sufficient for all ordinary purposes.

It may be as well to mention that the graduation on the scale is not proportioned to the amount of current flowing, it is fairly correct up to 20°, but as the needle moves further from parallelism with the coils, the effect of the current gets less and less, and at right angles, or 90°, it is practically *nil*. As detectors vary so much, it is useless to give any table of deflections for a certain amount of current, but each instrument can be tested, and the deflection when connected to a good cell noted for future use (the thick wire coils *must* be used for this test, as a very bad cell will give a good deflection through the fine wire coils).

THE BATTERY.—Our remarks will be confined to the two forms that in actual use have proved to be the best for telephonic purposes. For all private lines and the batteries at exchange subscribers' premises the prism form of Leclanché (No. 2 size) is the best. The number of cells used is usually four. The ringing battery at exchanges should consist of at least six cells, and each table should have a separate battery. The following is a description of this battery, with instructions for maintaining it in good order:—

The negative element of the old form of Leclanché cell is composed of a carbon plate placed in a mixture of coarsely powdered peroxide of manganese and carbon, the whole contained in a porous cell. The positive element consists of amalgamated zinc. The exciting liquid is a solution of sal-ammoniac. The solution has no chemical action either on the zinc or the peroxide of manganese so long as the cell is not at work. This is a great advantage, but the cell with the porous pot offers a rather high resistance, and the late M. Leclanché had for some time past been experimenting with a view to improvement. This he succeeded in effecting in the agglomerate form of cell by substituting movable plates for the porous pots. The materials used to form the depolarising plates are, in course of manufacture, submitted to a pressure of several tons, and, when joined to a carbon plate, compose the negative element of the cell. To fit up the agglomerate cells, place against each side of the carbon plate an agglomerate block, and stretch over them the two india rubber bands. These bands have each a solid part through which a hole has been bored to receive the zinc rod. By this means the zinc is kept from touching the negative element, thus avoiding injurious local action, the whole is held firmly together, and is ready to be placed in the glass jar.

The following quantities of sal-ammoniac should be used to charge the battery: For a No. 3 (small size) cell, 4oz.; for a No. 2 (medium size) cell, 6oz.; for a No. 1 (large size) cell, 10oz. In each case the cell should be filled with water so as to cover the agglomerate plates. If the cell is required for immediate action, the solution mixed in the above proportions should be prepared before being poured into the cell. The advantages of the new cell with agglomerate plates (as stated by the manufacturers) may be enumerated as follows:—

1. A much better use is made of the depolarising power of the manganese, as the reduction of it is more complete than in the porous pot form, where the manganese while being reduced clogs and prevents the action of the battery long before the whole of the manganese is reduced.

2. In consequence of the readier reduction of the manganese, the carbon plate is more rapidly depolarised than with the porous pot form, and consequently the electromotive force is more sustained.

3. The resistance is *extremely constant*, whatever the electrochemical work done by the cell may be, and will even tend to decrease in consequence of the formation of chloride of zinc, which is an excellent conductor.

4. The battery is ready for use immediately on charging, because the liquid is brought into direct contact with the negative and positive elements.

5. The renewal is exceedingly simple. When the battery becomes exhausted, the depolarising plates which are joined to the carbon plate have only to be removed, and fresh ones substituted.

6. By avoiding the use of porous pots the risk of breakage and deterioration is very much lessened, and the cost of renewal considerably reduced.

7. The trouble and cost of maintenance are next to nothing.

The Leclanché batteries are connected up like all other batteries—that is, the carbon of the first cell is left free, and the zinc is connected to the carbon of the second cell, the zinc of which is connected to the carbon of the third cell, and so on to the last cell, the zinc of which remains free, as shown in a future diagram of connections. When the two poles of the Leclanché battery are brought together, or, in other words, when the battery is at work, the solution of chloride of ammonium (sal-ammoniac) is decomposed, and an oxy chloride of zinc is formed, which is soluble in the surrounding liquid. The hydrogen and the ammonia go to the negative element, and are absorbed by the peroxide of manganese.

It is important that pure sal-ammoniac be used, as the impurities found in ordinary sal-ammoniac tend to cause a rapid consumption of the zinc rods.

Although the battery works well under ordinary conditions, the best results are obtained when the following precautions are taken:—

1. Keep the cells in a dry place of medium temperature.

2. Rub the inside of the neck of the glass cell (if it has not been previously paraffined) with oil or tallow, to prevent the possible creeping of the salts.

3. Take care that the contacts are always clean, and that the conducting wires are efficiently insulated.

4. When through evaporation the level of the water has fallen below the top of the agglomerate plates fresh water should be added.

5. If the liquid becomes milky or opaque, add sal-ammoniac until the liquid becomes clear again, or substitute a fresh solution.

6. Scrape the crystals off which sometimes settle on the zincs.

7. When inspecting see that no white lead is forming between the lead cap and carbon. If there is, the cells must be removed.

8. See that none of the solution gets on to the wires or terminals, it being very destructive, and rapidly causes a fault.

If care is taken in observing these precautions the battery cannot fail to give satisfaction. In exchanges where the work is very heavy the ringing battery had better consist of 6 to 8 gravity cells. These may be made as follows:—A glass jar 10in. high and 9in. diameter fitted with a porcelain or wood cover saturated with melted paraffin, a circular zinc ring with two projections cast on it which come through holes in the cover, and are held in this position by pins. One of these projections is fitted with a brass screw terminal, and, lastly, an inverted funnel made from 4lb. sheet lead pierced with holes. We shall show how the whole is placed in position in a future diagram.

To charge this battery drop copper sulphate down the neck of the funnel till it is full, then add pure cold water till it covers the zinc ring; the battery can then be joined up in the usual manner, *i.e.*, the strip of lead from the neck of the funnel going under the binding screw of the next zinc ring, and so on in succession. The last lead strip and zinc ring may then be joined by a wire, so as to short circuit the battery, and left thus for twelve hours. By that time the lead funnel will be found covered with copper, deposited from the sulphate, and so converted into the copper or negative element of the cell.

The only attention these cells require is:—Keeping the funnel neck full of sulphate, occasionally taking out the zinc and scraping off the copper deposit, and drawing off by means of a syringe some of the solution, replacing it with sufficient water to cover the zinc. Do not shake the battery after it is once in action.

The Leclanché cells may in all cases be retained for the transmitter local cell.

Always keep batteries in the coolest possible place (provided frost cannot reach them). Therefore the floor or a low shelf is preferable to their being placed near the ceiling. If obliged to put them in a warm place inspect more frequently.

(TO BE CONTINUED.)

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THE ELECTRICIAN.

TO CORRESPONDENTS.

All letters intended for insertion in THE ELECTRICIAN, *or containing questions, must be accompanied by the name and address of the writer, not necessarily for publication, but as a proof of good faith. No notice whatever will be taken of anonymous communications.*

All communications to be addressed to 396, Strand, London, W.C.

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ANSWERS TO CORRESPONDENTS.

C. S.—*Prof. Thompson's lectures on dynamos are published in pamphlet form by the Society of Arts, John-street, Adelphi, W.C., price one shilling.*

S. H.—*The best book on testing is that of Kempe, published by Messrs. Spon, Charing-cross. We have in hand some articles similar to those you suggest.*

A. G. CHEESMAN.—*Will write to you privately.*

J. A. FAHIE.—*Will send as many as we can, shortly.*

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MORE TELEPHONIC BATTLE.

Just when intelligence reaches us from the United States that a serious attempt is to be made to solve what American electricians call the "underground problem," we on this side of the Atlantic are attempting a solution of the overhead problem in a manner not at all serious, but, as one may venture to call it, rather frivolous. The proceedings at the Guildhall last Wednesday week, in the matter of two competing companies doing battle, so to speak, on the housetops, at the imminent risk of committing manslaughter, reveal a state of things which is happily rare in this country. There was, no doubt, a considerable amount of science displayed by the combatants, but it was not exactly of the electrical sort, and it contributed very little to the solution, scientifically, of any problem whatsoever. If the squabble the particulars of which Mr. Alderman Stone had to listen to with a grave countenance were not so amusing, we should be inclined to call it scandalous. It is really disgraceful that telephone wires should be liable to be wilfully tied together; and it is extremely unfair to users that their bells should all be set ringing by a powerful current impartially, but wantonly, distributed among those wires. At least, it would be disgraceful if it were a malicious act; but, in the absence of malice, its comic aspect remains uppermost, and as the comedy stopped short of a tragic ending, we are, on the whole, disposed to laugh at it.

Into the merits of this particular dispute we have no desire to travel, and, indeed, we know little or nothing of the merits of either of the parties concerned. Of their demerits we do know something, and will speak of them presently. But we are justified in joining in the laugh which a witness deposed to having been indulged in by the defendants' workmen when they playfully set the bells a-ringing belonging to the complainants. Proceedings were taken under the Malicious Damage to Property Act, probably because no other Act exists for the protection of property of the kind in question under which action could be taken. They are not Post Office wires, and are not, we should suppose, covered by the provisions of the Telegraph Act. At all events, the defendant company pleaded that the case was one for the Court of Chancery, not for the police court, and the suggestion may be taken as a repudiation of malice in the ordinary meaning of that term. There was a pretty suit going on in the first-named court, a suit which had already cost the litigants some £30,000, and evidently these *ex parte* proceedings on the top of the Wool Exchange were a mere episode in the main business which it was simply undignified to bring into an inferior court at Guildhall.

Such, at least, seems to have been the view of defending counsel, as advised by his clients. Possibly it is not a view that will be acceptable in English law. We have always frankly owned our indebtedness to America for the discovery of the telephone; we shall be equally prompt to acknowledge our obligation—such as it is—to the same country for a novel way of testing telephonic rights. It is not an English invention, but we shall be ready to adopt it if it prove successful. For, in sober earnest, we are exceedingly anxious to learn whether these telephonic companies, or any other companies who may shortly be expected to compete with the existing ones in the art of carrying wires over housetops and across leading thoroughfares, have any rights at all, and, if so, to have them clearly defined. It would appear that some people fancy they have exclusive right to the sky above any building on which a "derrick" of wires is erected, and that nobody else's wires may cross them. We sincerely hope the fancy may prove reality, for then there will be some limit—a wide limit, it is true, but still a limit—to the ever-increasing entanglement of overhead wires. We know that at present no place is too sacred, no place too dangerous, none too beautiful, for telephone interests to profane, imperil, or disfigure. But if it turned out that there are some which it would be *unlawful* for them to invade we should be thankful. It would really be a good investment for parish authorities, failing all other hindrance, to run a wire along either margin of the few thoroughfares not yet invaded by the telephone companies in order to prevent them crossing from side to side. We wish the Court of Chancery would solve this knotty legal problem with less than its accustomed slowness.

Meanwhile, we can see no escape from the nuisance of the

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overhead wire, except by removing it out of sight, as suggested at the meeting of the New York "Underground Committee." Unlike the overhead committee, whose abortive meeting on a roof adjoining Coleman-street, London, we referred to above, the New York committee arrived at unanimous conclusions after amicable discussion. It was resolved, first, that the public and the corporations desire to "relieve the thoroughfares from poles and wires." As a statement of fact this is valuable testimony from a city where the resources of civilisation are not generally objected to on the score of their hideousness. Secondly, it was affirmed that the time has arrived when it was expedient to make "an exhaustive examination of all devices and inventions pertaining to the subject of underground electrical communication, with a view to determine whether any inclusive system can be found" to establish such communication. An inclusive system, we take it, means a scheme of underground channels where every electrical wire can be lodged safe from the interference of over-zealous workmen in the employ of competing companies, from the risk of killing inoffensive citizens, and from the possible pecuniary danger of exasperating public opinion to such a pitch that the wires will receive summary orders to quit before any other receptacle is provided for them. On the whole, we are inclined to hope most from the New York method; but the London device may prove useful, to a certain extent, in the same direction, though by no means intended to be so.

THE LIGHTING OF THE REFORM CLUB.

The electric light is gradually winning its way, and as its excellencies are tested by experience its use will increase. There must necessarily be ups and downs, doubts and fears, but if the thing is of value it will assert its value. Club land is somewhat exclusive, and an examination of a new method of lighting not an easy matter to arrange. The Reform Club, however, is giving the system a trial. The dynamo used is the Elphinstone-Vincent 400 light shunt-wound machine, which is said to be nearly self-regulating, so that lamps may be turned on or off at will. This machine, we are told, was selected because it is calculated to supply sufficient current to lamps for the whole lighting of the club, and that if a non-regulating machine was used, the engine being old, and hardly adapted for such work, would increase the unsteadiness of the light. A secondary battery has been provided to obviate any unsteadiness, but has not been required. The motor is an Easton table engine, about six horse-power, hitherto used for pumping water, working a lift, &c., and overhauled for these experiments. With forty lamps the steam pressure is 38lb. per square inch. At first one end of the dining room, and the corresponding end of the library just above were lighted with twenty Swan lamps in each room. The lamps were arranged in a ring, and suspended about 14ft. from the floor. These lamps have been replaced by fifteen Woodhouse and Rawson lamps, with ground glass globes, and it is found that there is abundance of light. The walls of the library are covered with books, and the ceilings and pilasters are coloured olive green, relieved with much gilt carved work. A larger number of lamps could, therefore, be used, and in this room the naked lamps bring out the beauties of the decorations in a way that has never before been experienced. A crystal electrolier, by Defries, is now being suspended in the library, and it is proposed to light this with a mixture of ground and naked bulbs. Hitherto the Elphinstone-Vincent dynamo has been worked with six brushes. Future machines are to be worked with two, and these two by preference the pair at the top side of the commutator. The adjacent pairs of brushes are attached, but held off the commutator. In case of any trifling accident to the working brushes, one or both of them can be let down and the faulty brush removed without stopping the machine or causing any disturbance. Lord Elphinstone and Mr. Vincent find that their present size of commutator is amply large enough for the change, and that machines already built can have the arrangement of their brushes altered at a merely nominal cost. The advantages are that the workman has only two brushes to look after instead of six, that he has a pair in reserve, if needed, and, beyond this, the current in the external circuit is increased.

SECONDARY BATTERIES.*

On the evening of the 7th inst. Mr. C. T. Kingzett read a paper on the above-mentioned subject before the Society of Chemical Industry. After describing the many varied attempts which have been made during recent years to effect the economic storage of energy by means of electro-chemical processes, and incidentally pointing out their shortcomings, the author gave a general account of his own investigations, and the inventions to which they have led. These inventions are designed to obviate certain well-understood difficulties attending the so-called accumulators previously known to the public. For instance, the Faure-Sellon-Volckmar batteries are expensive, and exceedingly heavy; they suffer much loss by local action, and the formation of sulphate of lead which takes place during discharge at both elements causes loss of current energy in the charging process. Not only so, but the oxygen bearing plate or support is gradually, and, under certain circumstances, rapidly, destroyed by the ozonised oxygen set free thereat. Two supports made of metallic lead (or of lead alloyed with antimony) coated with red lead, and immersed in dilute sulphuric acid, constitute at the onset two primary batteries; that is to say, the minium oxidises the metal, and this action results immediately in the production of monoxide of lead, which subsequently is resolved into sulphate of lead by the action of the acid. Moreover, when such a combination is charged forthwith, the process results in an increase of the amount of peroxide of leads present at the one pole, and the formation of reduced lead at the other pole. At the negative pole, then, the conditions under which local action occurs are intensified; so are they, also, at the positive electrode (unless the whole of the minium be reduced), because, of course, reduced lead enters into reaction with minium much more readily than does the metal forming the support itself. Mr. Kingzett obviates all the difficulty at the positive pole by coating it with litharge instead of red lead, which, or the peroxide of lead, he still employs at the other terminal. A recently prepared paste of litharge and dilute sulphuric acid readily sets and hardens upon the supports, and such a mixture is much more easily reduced to the metallic state than is red lead, while the process requires also less hydrogen to effect it; that is to say, less electrolysis, and, therefore, a smaller expenditure of current energy. A mixture of red lead and acid sets or hardens almost as readily, and with this the oxygen-bearing support may be coated. Professor Frankland has, since the first patent was granted to Mr. Kingzett, patented the use of mixtures of oxides of lead and acids which form therewith insoluble salts, for placing in contact with the supports of secondary batteries without the use of any retaining material, but it will be seen that Mr. Kingzett claims originality in this particular, and also priority. He also claims the use of the two distinct compounds of lead, one at each of the respective supports.

He has also succeeded in effecting further new combinations, of which the following description may be taken in illustration:—Ordinary iron is employed to form both supports or electrodes, and they are prepared with the compounds of lead as already described, using for the electrolyte a bath of caustic soda or potash, or some neutral salt of an alkaline metal. Iron is, of course, much cheaper and much lighter than lead, and the reduction at the hydrogen-bearing plate takes place perfectly under the conditions of operating, the whole of the litharge being converted, so to speak, into metallic lead. The iron support used at the other pole is first coated either with magnetic oxide of iron, or with lead or otherwise, with the purpose of avoiding the attack upon this support by the oxygen, which would otherwise cause its gradual oxidation. Mr. Kingzett coats his negative plate of iron, for instance, with a dense and substantial thickness of lead by placing thereat the mixture of litharge and making it in the first place a hydrogen-bearing plate. When the reduction is complete, the support is ready for use as a oxygen-bearing plate, the attack of the oxygen being confined to the lead which is placed upon the support of iron. This metallic lead is in the fittest state for oxidisation, unlike the arborescent metal prepared by various expensive chemical processes, and unlike also the too spongy metal obtained by the electrolysis of an alkaline ley containing litharge dissolved in solution. The litharge being solid and dense, and confined in a limited space, the metal which results from its reduction is also continuous, dense, and greedily combines with oxygen, to form peroxide of lead. For use in an electrolyte of dilute sulphuric acid, a negative pole made of metallic lead or carbon may be similarly prepared with a coating of the reduced metal as just described.

Lastly, Mr. Kingzett constructs his supports or electrodes of a particular form, with the view of utilising the whole surface thereof, instead of a percentage only of the area, as in the per-

* The Paper of which this is an abstract will be published *in extenso* in the *Journal of the Society of Chemical Industry*.

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forated plates of the Sellon-Volckmar type. The general form of Kingzett's electrodes is that presented by a brush, and the projections corresponding to the bristles are made solid or hollow, and perforated if desired.

In illustration, it may be mentioned that Mr. Kingzett exhibited two small supports, made as follows:—A sheet of ordinary iron is drilled at periodic intervals, and into the openings are screwed perforated gas tubes of any desired bore cut to any desired length; to secure perfect continuity and conductivity the tubes are soldered at the back of the base plate. Or the whole apparatus may be cast in this form, and may be made either of lead or of iron, according to whether an acid, or neutral or alkaline, electrolyte is to be employed. The compounds of lead which are used, as previously described, may be placed inside (only) the perforated tubes, or both inside and outside, and also upon the surfaces of the base plate, in which latter case the entire surface of the electrodes is covered with active material. Above all, this arrangement permits of the intimate flow of the electrolyte in contact with all parts of the secondary batteries, and obviates the employment of any excess of the materials, since the distance between the tubes is subject to will, and so also is the diameter of the tubes, and from this it follows that the compounds of lead are entirely converted during the charging process into active materials, and a good proportion of the charge put into the batteries can be obtained therefrom, while obviously local action is avoided.

Mr. Kingzett hopes shortly to make arrangements for the supply of accumulators constructed under his patents.

THE TRANSMISSION OF POWER BY MEANS OF ELECTRICITY.

Some further experiments were made on the 4th of March with M. Marcel Deprez's machines at the workshops of the Northern (of France) Railway, near Paris, by a special committee appointed by the Academy of Sciences. The arrangement of the machines, the circuit, measuring apparatus, and connections were identical with those employed on the occasion of the previous experiments made on the 18th of February, and reported on by M. Tresca. A translation of this report will be found in our issue of the 7th April, and an illustration of the mode of connecting up the machines in our issue of the 31st March, p. 477, in which we also gave a translation of that portion of M. Tresca's report relating to the first series of experiments carried out on the 11th of February. The account of the further experiments of the 4th of March was presented to the Academy by M. Cornu in the name of the committee. It is a somewhat lengthy document, and therefore we do not propose to reproduce it in full. It commences by a brief allusion to the researches of Faraday, Gauss, Weber, and Siemens, describing the discovery of the former as the germ of all subsequent progress. Having repeated M. Tresca's description of the machines and the arrangement of the apparatus (see *The Electrician* for March 31), the report gives the following table of dynamometrical measurements obtained by the committee. These were under the charge of M. Tresca, M. Cornu being responsible for the electrical measurements:—

TABLE I.—*Dynamometrical Measurements* (taken with General Morin's dynamometer).

No. of experiment.	Dynamometer. No. of revolutions per minute. v	Dynamometer. Mean ordinate of the diagram. y	Generator. No. of revolutions per minute. N	Receiver. No. of revolutions per minute. n	Receiver. Weight on the brake.	Remarks.
		mm.			kg.	
I.	59	12·68	378	104	5	
II.	57	13·18	370	88	5	
III.	40	1·79	—	—	—	
IV.	157	3·53	—	—	—	
V.	132	14·43	850	602	5	Exp. interrupted.
VI.	144	14·29	925	709	5	
VII.	132	14·05	850	643	5	Brake badly held
VIII.	159	15·04	1024	799	5	
IX.	155	2·69	—	—	—	
X.	166	2·00	—	—	—	

	M.
Circumference of the pulley of the transmitting dynamometer, including the half-thickness of the driving band	$C + \frac{1}{2}\epsilon = 2{\cdot}623$
Circumference of the extremity of the lever of the brake on the receiver	5·00
Ratio of the speed of the generator to the dynamometer, deduced from the radii of the transmitting pulleys, plus the half thickness of the bands	6·35

TABLE II.

Electrical Measurements.

A.—*Before the Experiments.*

MACHINES	Generator	Approximate resistance of 4 inducers, 4 × 5 ohms	20
		Ditto of 2 rings, 2 × 18 ohms	36
		Total resistance R =	56·62
	Receiver	Approximate resistance of inducers	47
		Ditto of ring	36
		Total resistance r =	85·92
CIRCUITS		Telegraph line ρ =	160·62
		Additional resistance occasionally employed	295
GALVANOMETERS		No. 1 (used with a resistance of 50,000 ohms = g') g' =	55·23
		No. 2 (used with a shunt 1·23 ohms = s) g^2 =	29·73

B.—*Galvanometer Readings during the Experiments.*

(N.B.—M. Deprez's galvanometers were used.)

No. of experiment.	Difference of potential measured with Galvanometer No. 1, with an added resistance of 50,000 ohms. Zero of the Deflections.	Connected to the terminals of Generator.	Connected to the terminals of Receiver.	Current measurements made with Galvanometer No. 2 (shunted by 1·23 ohm). Zero of the Deflections.	Inserted in the Circuit.	Remarks.
I.	1·00	4·15	2·40	0·60	— 9·10	
II.	1·00	4·25	2·55	0·60	— 9·60	
V.	1·00	8·78	,,	,,	— ..	Interrupted.
VI.	1·55	10·60	8·85	0·60	— 9·60	
VII.	1·50	10·00	8·00	0·60	— 9·80	
VIII.	1·50	11·70	10·20	0·60	— 9·55	

The report then goes at considerable length into the coefficients of reduction adopted for the dynamometrical and electrical measurements, and experiments made to test the accuracy of the dynamometer and galvanometers. The reduction of the observations made led to the results given in Table III.

TABLE III.

Dynamometrical Results.

No. of the experiment.	No. of revolutions per minute. Generator N.	No. of revolutions per minute. Receiver n.	Mechanical work. Furnished by the pulley of the dynamometer T.	Furnished at the generator T m.	Received at the brake on the receiver T u.	Transmitted per revolution of the generator.	Dynamometrical return. Gross. $\frac{T u}{T}$	Transmission deducted. $\frac{T u}{T m}$
			h.-p.	h.-p.	h.-p.	h.-p.		
I.	378	104	3·838	3·296	0·578	0·00 153	0·151	0·176
II.	370	88	3·854	3·331	0·489	105	0·127	0·147
V.	850	602	9·771	7·665	3·344	393	0·342	0·435
VI.	923	709	10·556	8·259	3·939	427	0·372	0·477
VII.	850	643	9·514	7·408	3·572	420	0·375	0·482
VIII.	1024	799	12·267	9·751	4·439	433	0·362	0·456

From this table it appears that the work absorbed by the generator and transmitted to the receiver increased with the speed of the generator. The grand fact that is established is that nearly 4½ horse-power has been transmitted through a resistance of 160 ohms, representing a double telegraph line of 8·5 kilometres long (9295·60 yards). The gross return will be represented by 37½ per cent. of the work expended, if we take into account the losses which every motor sustains when working. But if we neglect the mechanical motor altogether, and deal exclusively with the result obtained by successive transformations of energy, we may call the dynamometrical return 48 per cent.

The figures in Table III., combined with those given in M. Tresca's previous report, seem to indicate that, if the quantity of work transmitted increases with the speed of the machines, the return attains its maximum when the speed of the generator reaches about 850 revolutions. It would seem that the generator had not reached its maximum power, and that a quicker speed would permit of a much larger amount of work being transmitted. Experiment confirms this view in another way; with such high speed for the generator, the receiver which was em-

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ployed, and which was an old Gramme machine modified, appeared to have reached its maximum power. Its collectors were covered with continuous and extremely brilliant sparks, and often quite a circle of fire would suddenly surround the whole periphery of the shaft. The machine was saturated, and would have been in danger of destruction if a larger amount of electrical work had been laid on it. The generator, on the other hand, worked in a far more regular manner, and the sparks at the collectors were slight. It is very probable, therefore, as has been suggested by M. Deprez, that far better effects would have been obtained if the receiver and generator had been identical.*

The electrical results are given in

TABLE IV.

Electrical Results.

No of the experiment.	No. of revolutions per minute of the Generator N	No. of revolutions per minute of the Receiver n	Current C	Difference of Potential at the terminals of the Generator U	Difference of Potential at the terminals of the Receiver u	Effective resistance of the telegraph line $\frac{U-u}{C}$	Electromotive force developed in the Generator E	Electromotive force developed in the Receiver e	Electrical return $\frac{e}{E}$
			amp.	volts	volts	ohms	volts	volts	
I.	378	104	2·39	722	321	167	855	116	0·136
II.	370	88	2·52	745	355	155	888	138	0·155
VI.	923	709	2·52	2086	1685	159	2229	1468	0·658
VII.	850	643	2·57	1937	1479	179	2083	1258	0·604
VIII. ...	1029	799	2·50	2338	1994	138	2480	1779	0·717
					Average	159·6			

The first result demonstrated by this table is that the resistance offered by the telegraph line during the transmission, that is with a current of about 2·5 amperes, remained nearly steady at 160 ohms, the resistance which it was found to offer with a current of ·01 ampere during the preliminary tests. The average of 159·6 (see table) coincides very nearly with 160. The divergence of the figures is accounted for by the variations in the speed of the machines, and also by the impossibility of making the measurements of U, u, and C absolutely simultaneous. This identity between the effective and measured resistances of the line is very important, showing as it does the agreement of theory with practice, when the phenomena of the transformation of energy in a circuit are analysed. It shows that the energy necessary to overcome the resistance of 160 ohms is practically equal to the theoretical value found for it. This energy, expressed in kilogrammetres per second, is equal to $\frac{\rho C^2}{g}$, and, in horse-power, $\frac{\rho C^2}{75\,g}$. As the current remained constant, or nearly so, at 2·5 amperes, the loss of mechanical work is equal, for all the experiments, to about

$$\frac{160 \times \overline{2 \cdot 5}^2}{75 \times 9 \cdot 81} = 1 \cdot 358 \text{ horse-power.}$$

We know that this amount of energy is diffused in the shape of heat.

Another result predicted by theory is the ratio of the electromotive force to the speed, the current being constant; if, in fact, we calculate the quotients

$$\frac{E}{N} \text{ and } \frac{e}{n},$$

we find

Experiments	I.	II.	VI.	VII.	VIII.
Generator $\frac{E}{N}$.	2·26	2·40	2·41	2·45	2·42
Receiver $\frac{e}{n}$.	1·12	1·57	2·07	1·96	2·23.

The ratio for the generator is very satisfactory, as it is also for the receiver in those cases where the speed n was accurately measured.

The last column of Table IV. gives the ratio of the E.M.F.'s $\frac{e}{E}$ developed in each machine. It has long been known that this ratio represents the dynamometrical return when the induction phenomena which always accompany the production of the principal current in dynamo machines are neglected. Thus we have, according to the well-known theory of the conservation of energy,

$$E\,C = T_m,\; e\,C = T_u,$$

calling T_m the work actually given to the generator and T_u the work received at the receiver. From which we conclude that

$$\frac{e}{E} = \frac{T_u}{T_m},$$

which demonstrates the identity of the two returns.

It will be remarked that E and e are united by Ohm's law, so that we may write, calling R and r the internal resistances of the two machines,

$$(R + r + \rho)\,C = E - e,$$

that is to say,

$$\rho\,C = (E - RC) - (e + r\,C) = U - u,$$

a relation exactly verified above.

Experiment shows that the electrical return is far higher than the dynamometrical return, a grave objection to the electrical theory of the transmission of power. Happily the origin of this difference is readily found. As we have seen that this difference does not originate in the line of transmission, it can only be met with at the localities where the transformation of electrical energy into mechanical energy, and *vice versâ*, takes place. Now, experiment gives the value of the electrical energy in each machine; we can, therefore, compare it directly with the dynamometrical figures T_m and T_u. We know that electrical energy is expressed in horse-power by dividing the products E C and e C by 75 g ($g = 9 \cdot 81$). By this means we can readily form the following table:—

TABLE V.

No. of the experiment.	Electrical energy developed in. The generator $\frac{E\,C}{75\,g}$.	Electrical energy developed in. The receiver $\frac{e\,C}{75\,g}$.	Mechanical work. Given to the generator T_m.	Mechanical work. Received at the receiver T_u.	Practical coefficient of transformation. For the generator.	Practical coefficient of transformation. For the receiver.
	h.-p.	h.-p.	h.-p.	h.-p.	H.	h.
I.	2·668	0·362	3·296	0·578	0·809	1·596 ?
II.	2·923	0·454	3·331	0·489	0·877	1·077 ?
VI.	7·336	4·831	8·259	3·939	0·888	0·815
VII.	6·991	4·222	7·408	3·572	0·944	0·846
VIII.	8·097	5·809	9·731	4·439	0·832	0·764
			Average		0·870	0·806

It will be seen that for each of the machines the energy developed is inferior to the energy expended, of which it should theoretically be the equivalent. In the two cases, although the transformations are of inverse character, there is a loss of useful energy, so that if we call the practical coefficient of transformation of the generator H, and that of the receiver h, corresponding to their speeds, we must substitute for the equations of the conservation of energy the following:

$$E\,C = H\,T_m,\; h.e\,C = T_u,$$

so that the dynamometrical return becomes

$$\frac{T_u}{T_m} = H\,h\,\frac{e}{E}.$$

We thus see why the dynamometrical return is always less than the electrical return. The coefficients h and H evidently depend upon the construction of the machines and their speeds. The figures given in this report and those obtained on the 18th February induce the belief that this product, approaching unity for slow speeds, diminishes rapidly with high speed.

The report then discusses the relative efficiency of the two machines used, and the means adopted by M. Deprez to improve that efficiency for the special object in view, viz., the transmission of power. It concludes with the following words:—

"The committee is not qualified to judge of the economic value and the industrial future of the results obtained; but after a most careful examination of the *apparata* and principles employed, it does not hesitate to proclaim the importance of the facts that have been demonstrated. In consequence, it proposes that the academy should congratulate M. Marcel Deprez on the important progress he has made towards the solution of the very interesting problem of the electrical transmission of power, and encourage him to pursue his labours, and continue, as he has done up to the present, to place the resources of an ingenious mind at the service of the principles of electrical science."

* When a trial was made with this generator with the view of determining its characteristic at 740 revolutions per minute, the current in a short circuit (250 ohms), according to M. Deprez's measurements, reached 9·80 amperes, which corresponds to an expenditure of 30 horse-power; it might, at the same time, it appears, have accidentally absorbed as much as 50 horse-power.

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A HISTORY OF ELECTRIC TELEGRAPHY TO THE YEAR 1837.

BY J. J. FAHIE, MEMB. SOC. TEL. ENGS. AND ELECS.*

(CONTINUED FROM PAGE 22.)

The Starry Galileo had his say on the same subject, and, as we may expect, said it well: "You remind me," says he, "of one who offered to sell me a secret art, by which, through the attraction of a certain magnetic needle, it would be possible to converse across a space of two or three thousand miles. And I said to him that I would willingly become the purchaser, provided only that I might first make a trial of the art, and that it would be sufficient for the purpose if I were to place myself in one corner of the room and he in the other. He replied that, in so short a distance, the action would be scarcely discernible; so I dismissed the fellow, and said that it was not convenient for me just then to travel into Egypt, or Muscovy, for the purpose of trying the experiment, but that if he chose to go there himself, I would remain in Venice and attend to the rest"! ("Dialogus de Systemate Mundi," 1632, p. 88.†)

Cardinal Richelieu's system of espionage was so perfect that he was regarded (and feared) by his contemporaries as a dabbler in "diabolical magic." He was supposed to have possessed either a magic mirror, in which he could see all that went on in the world, or the equally magic magnetic telegraph. *A propos* of this, we find the following passage in the "Letters writ by a Turkish Spy," a work which has been attributed by the elder Disraeli to John Paul Marana:—"This Cardinal said, on another time, that he kept a great many courtiers, yet he could well enough spare them; that he knew what passed in remote places as soon as what was done near him. He once affirmed he knew in less than two hours that the King of England had signed the warrant for the execution of ———. If this particular be true, this Minister must be more than a man. Those who are his most devoted creatures affirm he has in a private place in his closet a certain mathematical figure, in the circumference of which are written all the letters of the alphabet, armed with a dart, which marks the letters, which are also marked by their correspondents, and it appears that this dart ripens by the sympathy of a stone, which those who give and receive his advice keep always at hand, which hath been separated from another which the Cardinal has always by him; and it is affirmed that with such an instrument he gives and receives immediately advices." (13th letter, dated Paris 1639, Vol. 1.)

The learned Physician, Sir Thomas Browne, has some cautiously worded sentences on the mythical telegraph, which are worth quoting. "There is," he says, "another conceit of better notice, and whispered thorow the world with some attention; credulous and vulgar auditors readily believing it, and more judicious and distinctive heads not altogether rejecting it. The conceit is excellent, and, if the effect would follow, somewhat divine; whereby we might communicate like spirits, and confer on earth with Menippus in the moon. And this is pretended from the sympathy of two needles, touched with the same loadstone, and placed in the center of two abecedary circles, or rings, with letters described round about them, one friend keeping one, and another the other, and agreeing upon an hour wherein they will communicate. For then, saith tradition, at what distance of place soever, when one needle shall be removed unto any letter, the other, by a wonderful sympathy, will move unto the same. But herein I confess my experience can find no truth, for having expresly framed two circles of wood, and, according to the number of the Latine letters, divided each into twenty-three parts, placing therein two stiles, or needles, composed of the same steel, touched with the same loadstone and at the same point. Of these two, whenever I removed the one, although but at the distance of but half a span, the other would stand like Hercules pillars, and, if the earth stand still, have surely no motion at all."—("Pseudodoxia Epidemica," Book II., chap. 3).

The "Scepsis Scientifica" of Joseph Glanvill, published in 1665, and which, by the way, secured his admission to the Royal Society, contains, perhaps, the most remarkable allusion to the prevailing telegraphic fancy. Glanvill, albeit very superstitious, was an ardent and keen-sighted philosopher, and held the most hopeful views as to the discoveries that would be made in aftertimes. In the following passages he clearly foretells, amongst other wonders, the discovery and extension of telegraphs:—

"Should those heroes go on as they have happily begun, they'll fill the world with wonders. And I doubt not but posterity will find many things that are now but rumours verified into practical realities. It may be some ages hence a voyage to the southern unknown tracts, yea, possibly the moon, will not be more strange than one to America. To them that come after us, it may be as ordinary to buy a pair of wings to fly into the remotest regions as now a pair of boots to ride a journey. *And to confer at the distance of the Indies by sympathetic conveyances may be as usual to future times as to us in a literary correspondence.*"—C. xix.

"That men should confer at very distant removes by an extemporary intercourse is a reputed impossibility, yet there are some hints in natural operations that give us probability that 'tis feasible, and may be compast without unwarrantable assistance from dæmoniack correspondence. That a couple of needles equally toucht by the same magnet being set in two dyals exactly proportion'd to each other, and circumscribed by the letters of the alphabet, may effect this magnale hath considerable authorities to avouch it. The manner of it is thus represented. Let the friends that would communicate take each a dyal; and having appointed a time for their sympathetic conference, let one move his impregnate needle to any letter in the alphabet, and its affected fellow will precisely respect the same. So that would I know what my friend would acquaint me with, 'tis but observing the letters that are pointed at by my needle, and in their order transcribing them from their sympathized index as its motion directs: and I may be assured that my friend described the same with his, and that the words on my paper are of his inditing. Now, though there will be some ill contrivance in a circumstance of this invention, in that the thus impregnate needles will not move to, but avert from each other (as ingenious Dr. Browne in his 'Pseudodoxia Epidemica' hath observed), yet this cannot prejudice the main design of this way of secret conveyance, since 'tis but reading counter to the magnetic informer, and noting the letter which is most distant in the abecedarian circle from that which the needle turns to, and the case is not alter'd. Now, though this desirable effect possibly may not yet answer the expectation of inquisitive experiment, *yet 'tis no despicable item, that by some other such way of magnetick efficiency it may hereafter with success be attempted*, when magical history shall be enlarged by riper inspections, and 'tis not unlikely but that present discoveries might be improved to the performance."—C. xxi.

At the end of this chapter we give a list of references, as complete as we could make it, which will be useful to those of our readers who may wish to pursue the subject. It will also be instructive from another point of view, for it illustrates, in a very complete way, what Professor Tyndall has so well called the "menial spirit" of the old philosophers.* Notwithstanding that some of the more enlightened authors endeavoured laboriously to disprove the story, it was, for the most part, blindly and unquestioningly repeated, by one writer after another—credulous and vulgar auditors, as Sir Thomas Browne says, readily believing it, and more judicious and distinctive heads not altogether rejecting it, amongst whom we are tempted to reckon the learned knight himself.

Of those who stoutly and, at an early period, combatted the story, Fathers Cabeus and Kircher deserve to be mentioned—the one for the excellence, and the other for the vehemence of his observations. Those of the former are particularly remarkable, as containing a hazy definition of the "lines of force" theory—a theory which Faraday has turned to such good account in his "Experimental Researches." Cabeus, as well as I can understand him, says, in his tenth chapter:—"The action by which compass needles are mutually disturbed is not brought about by sympathy, as some persons imagine, who consider sympathy to be a certain agreement, or conformity, between natures or bodies which may be established without any communication. Magnetic attractions and repulsions are physical actions which take place through the instrumentality of a certain quality, or condition, of the intervening space, and which extends from the influencing body to the influenced body. I cannot admit any other mode of action in magnetic phenomena; nor have I ever seen in the whole circle of the sciences any instance of sympathy or antipathy (at a distance). . . .

"That which is diffused as a medium (or, that quality, or condition, of the intervening space) is thin and subtle, and can only be seen in its effects; nor does it affect all bodies, only such as are either conformable with the influencing body, in which case the result is a perfecting change (or sympathy = attrac-

* The author reserves all rights of translation.

† It is curious that Kepler appears to have believed in the efficacy of the sympathetic telegraph. See Fournier's "Le Vieux Neuf," Paris 1857, Vol. I., page 200.

* "The seekers after natural knowledge had forsaken that fountain of living waters, the direct appeal to nature by observation and experiment, and had given themselves up to the remanipulation of the notions of their predecessors. It was a time when thought had become abject, and when the acceptance of mere authority led, as it always does in science, to intellectual death. Natural events, instead of being traced to physical, were referred to moral causes; while an exercise of the phantasy, almost as degrading as the spiritualism of the present day, took the place of scientific speculation."—Tyndall's address to the British Association at Belfast, 1874.

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tion), or non-conformable, in which case the result is a corrupting change (or antipathy = repulsion). This quality is, I repeat, thin and subtle, and does not sensibly affect *all* intermediate (*i.e.*, neighbouring) bodies, although it may be disseminated through them. It only shows a sensibly good or bad effect according to the natures of the bodies opposed to one another.

"Bodies, therefore, are not moved by sympathy or antipathy, unless it be, as I have said, through the medium of certain essences (forces) which are uniformly diffused. When these reach a body that is suitable, they produce certain changes in it, but do not affect (sensibly) the intervening space, or neighbouring non-kindred bodies.—Thus the sense of smell is not perceived in the hand, nor the sense of hearing in the elbow, because, although these parts are equally immersed in the essences (or forces) they are not suitable or kindred in their natures to the odoriferous or acoustic vibrations."* ("Philosophia Magnetica," &c., chap. 10.)

Kircher scouts the notion in no measured terms; after soundly rating the propagators of the fable on their invention of the terms *chadid*, *almagrito*, *theamedes*, *almaslargont*, and *calamitro*—vile jargon, which, he says, was coined in the devil's kitchen—he thus delivers himself:—"I do not recollect to have ever met anything more stupid and silly than this idiotic conception, in the enunciation of which I find as many lies and impositions as there are words, and a crass ignorance of magnetic phenomena withal. In their craving after something wonderful and unknown they manufactured a secret by means of barbarous, and high-sounding words, and by imitating the forms of recondite science, with the result that even they themselves could not understand their own words" ("Magnes, sive de arte magnetica," Book II., Part IV., Chapter 5).

(TO BE CONTINUED.)

ELECTRICITY AS A MOTIVE POWER.†

BY PROFESSOR GEORGE FORBES.

(CONTINUED FROM PAGE 24.)

I have said that, to produce a good mechanical effect with a dynamo used as a motor, it is necessary to drive it at a high speed. This speed is generally too great for ordinary mechanical applications. For example, we do not require the wheels of a tramcar to turn at anything like a speed of 800 turns a minute. In such applications, then, it becomes necessary to reduce the speed by suitable gearing. Thus, in the electrical tramcars which have been constructed hitherto, belting has been used, or some equivalent. This is an awkward expedient, and one which, in practice, is found to give much trouble. I am inclined to think that, in making an electrical railway, it would be preferable to make the wheels of small diameter, and attached directly to the axle of the motor. This seems to be by far the best plan in the present state of affairs. It may be that a motor will be found which will work economically at a lower speed; but with those which are now at our disposal it would be best to work with very small wheels.

We now come to consider, directly, the transmission of energy to a distance. There are two separate kinds of application. One is to fixed motors, the other to locomotives. Let us begin with the stationary motors. There is no doubt that if electricity be capable of transferring the water-power of rivers to the centres of mechanical industry, if it be capable of introducing economy by burning coal at the pit mouth, or the bottom of the pit shaft, then we have a vast engineering industry ready to open out.

It is not until we have sat down and worked out from experimental data the cost of installation and maintenance, that we can pronounce an opinion on the merits of such schemes. When we want to send a large quantity of energy to a distance, through a thin wire, we must use the highest electromotive force which we consider safe, and the most powerful current which the conductor will bear without either fusing or injuring its supports by heating, and then we have no means of increasing the amount of energy which we can send, except by increasing the size of our conductors. Unfortunately, when we double the weight of our conductors we do not double the current which we can pass through them. Hence there must necessarily be a limit to the quantity of energy which can be sent along a single line, which limit is reached when the cost of the conductor becomes too great. When a limit is thus attained, the only way of increasing the transmission of energy economically is by increasing the number of systems of conductors, or else by introducing means of cooling the conductors. These are the considerations which have guided M. Deprez in his experiments. But Sir William Thomson has shown that the loss of horse-power in heating the conductor more than compensates for the expense of thicker conductors. For economy, we ought to have the value of horse-power thus worked equal to the value of interest and depreciation of conductors.

In such an installation we require to consider not only the quantity of power which can be transmitted, but also the efficiency of the arrangement. Now, the efficiency varies with the quantity of power which is transmitted. If we transmit very little energy we get a high efficiency, nearly = 1; if we transmit the maximum amount of energy possible the efficiency is ½. In fact, the work done by the motor is proportional to the efficiency minus the square of the efficiency:

where $w = 4\,M\,(e - e^2)$,
M = the maximum work possible,
e = the efficiency,
w = the actual work returned,

and consequently, when the efficiency is nearly equal to unity, the work done is zero. It is found in practice to be preferable to get nearly the maximum work out of a machine, rather than to increase the size and cost of the machines, in order to get a certain amount of work from the apparatus.

Of course it is only after long experience that we shall know what is the maximum power which we can send along a wire, and what limits must be put to the electromotive force which we use. M. Marcel Deprez has spent much time and labour on making practical tests of this nature. One of these formed a chief attraction at the Munich Exhibition last year, where he used an iron telegraph wire, 4mm. diameter (or a sixth of an inch), and transmitted ½ horse-power to a distance of 35½ miles. He has since been carrying on experiments of the same kind at Paris. The results have lately been published, and I shall return to them.

One of the chief things which I proposed to myself when I was asked to read a paper here was to give some account of the experiments which I saw at Munich. I was very much struck indeed with the transport of energy by Mr. Schuckert, of Nürnberg, not that there was any new principle involved, but I had never before seen so much as 5 or 6 horse-power conveyed by a thin wire so far as three and a-half miles. The power was derived from a turbine, at Hirschau, beyond the English gardens. These turbines are employed on a locomotive factory, no steam being used in any of the shops. They have thus 260 horse-power at their disposal. The machine at Hirschau was of a larger size than the motor in the exhibition. This is a point on which Mr. Schuckert has made careful experiments. This machine, which was driven by the turbine, worked a number of agricultural machines during the day, and served to light thirteen Pilsen lamps at night, both being in the exhibition building. The turbine being a very large one, and revolving slowly, transmitted its power to the dynamo by belts. A turbine is a very convenient motor for a dynamo, for it happens that when we are using a dynamo requiring the whole power of the turbine the proper speed for each is nearly the same, so that the dynamo may be attached directly to the shaft of the turbine, which is, of course, a very great convenience and a saving of power. In my experiments, in conjunction with Dr. Young, on the velocity of light, at Wemyss Bay, I made use of such an arrangement for producing the electric light. A small Siemens machine was attached directly to a Thomson's vortex turbine with horizontal shaft. The water was led from a distance of nearly a mile. The convenience of being able to start the electric light by merely turning a handle was very great indeed, and I can recommend this arrangement to any one who has water-power at his disposal.

But to return to the Hirschau installation. A pair of No. 7 copper wires conveyed the current, one-eighth of the E.M.F. being wasted in heating the wire. This installation, taken as a whole, was much to be admired. I do not say that there was anything new or much information to be gained from it, but it showed to every one visiting the exhibition a good working, practical installation. Mr. Schuckert has been good enough to give me the results he has obtained from two experiments with different sets of machines. All the four machines with which these experiments were made are constructed for generating a current of eight amperes. In one experiment the generator was constructed for fifty-five incandescent lamps, with a motor constructed for thirty-three lamps (the lamps being in compound

* "A brief letter from a young Oxonian to one of his late fellow-pupils upon the subject of Magnetism," London, 1697, contains, at page 10, a "draught" which illustrates very well the arrangement of magnetic lines of force, and which differs but little from the graphic representations of the present day. The curious little pamphlet is one of many gems in Mr. Latimer Clark's library.

† Paper read before the Society of Arts on Wednesday, May 2, 1883.

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parallel). In the other he used as generator a machine for about 150 lamps, with a motor made for eighty-eight lamps. The particulars of the machines are given in the following table, from which we see that in each case 36 per cent. of the energy put into the generator was reproduced as work done by the motor :—

	First Experiment.	Second Experiment.
Type of Generator	TL 3	TL 5
Type of motor	TL 2	TL 4
Difference of potential—		
(1) At terminals of generator	300	700
(2) ,, ,, motor	230	600
Resistance of leaders	6 ohms.	12 ohms.
H.-P. spent on generator	4·4	12·8
H.-P. given by motor	2·5	5·8
Efficiency (per cent.)	36	36

I give you these figures, not because they show any wonderful performance, but because it is desirable to have as many facts as possible when any new idea is being developed.

You see that, in these experiments, the aim has not been so much to get a high efficiency as to get a high amount of power developed. This is what ought always to be done, while the machines form the chief item of cost.

Let us now speak of the experiments of M. Marcel Deprez. In 1881, M. Deprez published the theory of transmission of energy to a distance, by means of a thin wire. It is a theoretical fact that, if you get a certain return by using a given generator and a given receiver, and with a certain length of wire between the two, you can double the distance with the same results as to power, using the same thickness of wire, if you construct a new generator and a new receiver, wound with smaller wire, so as to have double the resistance of wire wound, the other dimensions of the machine being unchanged. This had been known before, and the theory had been fully worked out by Frölich and others. But Deprez had the credit of working out numerical examples, and of afterwards putting the theory to the test of experiment. In his first paper, he started with some experiments made at Chatham, in which two Gramme machines were used, one as generator, the other as receiver; when through a line-resistance equal to that of either machine, a return of 50 per cent. was obtained. He then showed that theoretically a similar pair of machines could be constructed so as to transmit 50 per cent. of the energy to a distance of 100 kilometres, an ordinary telegraph wire being used, 4 mm. thick, giving a resistance of 9 ohms to the kilometre. He also stated that 12 horse-power being used by the generator, 6 horse-power would be delivered by the receiver. I do not consider that the theory in this paper was quite clear, but the main point was proved.

After the the publication of this paper, the Munich Exhibition was a thing of the immediate future, and M. Deprez was invited to make his experiment with a distance of sixty kilometres. The resistance of a telegraph wire of this length, using the earth for the return, was 475 ohms. Consequently two machines were made of the normal type, like an "A" Gramme, each of 453 ohms resistance. These machines developed very high electromotive forces (about 2,000 volts), and when they were installed it was naturally discovered to be impossible to use the earth as a return. Consequently another wire was used, increasing the resistance to 950 ohms. This militated against the complete success of the experiment, and I think it is unfortunate that, in their desire to assert the success of the experiments, the friends of M. Deprez withheld this fact from the public, and so led many people to believe that the theory was inexact. As a matter of fact, owing to the great resistance of the line, 60 per cent. of the total electric effect was used up in heating the circuit, instead of 40 per cent., as had been calculated. In order, then, to get a satisfactory return, it was necessary to allow the receiver to do very little work. Thus, in the trial made by the committee of experiments before the machine broke down, only 0·433 of a horse-power was utilised at Munich, and there was a return of 39 per cent. of the power put into the machine at the distant station of Miesbach.

These experiments were of a very high degree of interest, and M. Deprez deserves the thanks of scientific men for the zeal he showed in carrying them out. Let us see, now, whether an economy would thus be introduced by burning coal at the pit mouth, and transmitting power as in the Miesbach experiment. Allowing 3lb. of coal per horse-power per hour, if we work twenty-four hours a day for 300 days in the year, we have almost exactly 10 tons of coal per horse-power per annum. Suppose the coal costs 5s. a ton at the pit mouth, and a ½d. per ton for transport over the kilometre, it follows that the cost of furnishing 0·433 of a horse-power at Munich by transport of coal would be the cost of 4·33 tons of coal, and their transport over 60 kilometres, amounting to £1 11s. 6d. The cost of coals to work the machine at Miesbach, with a duty or efficiency of 39 per cent., would be £2 19s. Let us assume the machines to cost £100 together, then, neglecting the cost of the telegraph wire, and allowing 15 per cent. for interest and depreciation of the machines, neglecting also the extra cost of the larger steam engine required at Miesbach, we have an annual expense of £17 19s. for the power delivered electrically at Munich against £1 11s. 6d. for the same power delivered by the transport of coal. Even if the machines cost nothing there would be a loss; if the power cost nothing there would also be a loss. It is folly to use machines costing so much only to produce ½ horse-power.

I have no doubt that M. Deprez could have got more than a ½ horse-power at Munich, but had he attempted this it would have been at a cost of efficiency. It cannot be too constantly borne in mind that, in electro-mechanics, you can increase your efficiency almost up to unity, but at a sacrifice to the total amount of work transmitted. But it must also be constantly remembered that you increase your total work up to a certain maximum, but at the cost of efficiency. The maximum efficiency is obtained when the load is so great that the motor is only just able to turn round. The efficiency is greatest when the load is so light that the motor turns nearly as quickly as the generator. I repeat that an erroneous idea has been promulgated that we ought always to run motors at a speed approaching to this condition of maximum efficiency. But if this be done, the return of work is insufficient to pay for interest and depreciation on the plant required.

The very important experiment of M. Deprez, at Munich, is able to give us much information for future use. Among other facts, we learn that with machines of the type described by him, 2,000 volts is too high an electromotive force to employ. The reason is that it is impossible to prevent the contact of the brushes from being sometimes accidentally broken. In such a case it was found that the electromotive force developed by the extra current is sufficient to ruin the insulation.

Another matter deserving of attention is the relative size of the generator and motor. M. Deprez employed two machines of equal size. This slightly simplifies the theory, but it is certainly not the most advantageous arrangement, and we are much in want of accurate measurements on this head.

From what has been said, it is clear that the Deprez experiment at Munich was, commercially, a failure. You might, at first sight, think that if a thoroughly scientific experiment like this was a commercial failure, there are no cases in which it would be a commercial success. This is by no means the case. Since the time of the Munich Exhibition, M. Deprez has been occupied with experiments of a far more practical nature, with a line of 160 ohms resistance. In the latest experiments, where the effects of friction were deducted, a return of 47½ per cent. was obtained, and 4·4 horse-power of work was actually given off by the motor. Judging from the Hirschau experiment I should say that if a fall of water be used as the motive power, we can install a turbine and dynamos, which shall transmit 6 horse-power through a resistance of 12 ohms, at a cost of £200, neglecting the unknown cost of the conductor. If this power were in used a place where coal costs 20s. per ton, the cost of fuel for 6 horse-power would be about £60 per annum. The interest and depreciation on the boiler and steam engine would be about £30 per annum, making in all £90 per annum, exclusive of wages. Electrically transmitted, the interest on plant at 15 per cent. would be £30 per annum, exclusive of wages. This difference of £60 per annum, after deducting from it the interest and depreciation of the conductor, is so enormous that it is easy to see what a large saving would be effected in any installation where there is a large consumption of power. There are many factories where it is essential to use a high-priced coal, but if the power could be conveyed electrically from a distance of a few miles an immense saving would be effected by employing a cheaper kind of coal. When water power is used it often happens that we can convey the cables along the bed of the river. This preserves the insulation and keeps the conductor cool, so preventing the usual increase of resistance by heating.

In some towns, and notably in Sheffield, the whole of the water supplying the town comes from reservoirs at a very great height. The very large quantity of energy of this water is at present absolutely wasted; and although coals are not dear in Sheffield, and manufacturers are permitted to burn the most smoky kind of coal in the centre of the town, yet the employment of this waste water-power would add very considerably to the commercial prosperity of the town, and the water would be injured in quality no more by passing through turbines, than by passing through the present pipes. If this power were distributed electrically, the benefit to the community would be great indeed.

At the site of the Severn Tunnel there is a width of river of two and a-half miles, where the average rise of tide is thirty feet. If the average rate of flow across this section were one

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mile per hour, we could utilise 100,000 horse-power, and the market value of that power is something like £1,000,000 per annum, which is now allowed to be wasted. It is worthy of the most serious consideration whether it would not be worth while to erect the enormous engineering works which would be required to utilise this wasted energy, or rather a portion of it. Assuming the interest and depreciation on the turbines and dynamos to be at the rate of £2 per annum per horse-power (and it would be far less than this for a large installation), it is easy to see that a time will come when this source of wealth will not be allowed to be wasted.

I wish to draw special attention to this point, because I have frequently heard people say, with regard to the utilisation of the tides, "Oh, that is out of the question; Sir William Thomson has proved that the area required to produce 100 horse-power is so great that it would be more worth while to reclaim the land and cultivate it." Now, Sir William never said such a thing. It is true that at the York meeting of the British Association he showed what area would require to be enclosed in order to produce 100 horse-power on the supposition that there was a rise of tide of only 6ft. 7in. (two metres). And he made use of the following expression :—"Thus we are led up to the interesting economical question, whether is forty acres . . . . or 100 horse-power more valuable." But in the case I am considering, the height of the tide is six times that contemplated by Sir William, and the question is rather "whether is forty acres or 600 horse-power more valuable." The estimate I made above, as to the value of a horse-power, agrees with Sir William's; and the value of 600 horse-power is £6,000 per annum. I confidently state that the reclaimed land on the Severn would not be worth £150 per acre per annum. I have taken the site of the Severn Tunnel as an example, but there are many other places available, and I have little doubt that the industrial population at Bristol will soon realise the wealth of power at their doors.

Some people in this country are timid about the introduction of large turbines. This, I need hardly say, is a gross prejudice. At Connecticut, Massachusetts, 30,000 horse-power is derived from the river by turbines. At Narva, near St. Petersburg, one firm uses 12,000 horse-power, and the size of the turbines used, which were made at Augsberg, was limited only by the size of the tunnels on the railways by which they had to be conveyed. At Munich I saw 260 horse-power rendered available by means of turbines with a fall of less than two metres. In the remote valleys of Italy there are several installations of incandescent electric lighting by means of turbines driving the machines of Messrs. Crompton. In Scotland, too, we have powerful turbines. Mr. Pirie, the paper maker, has introduced, near Aberdeen, turbines working up to nearly 1,000 horse-power. At Greenwich large overshot wheels are employed. The Shaws Water Worsted Company are now replacing one of these 200 horse-power by a turbine. In Lancashire water-power is also extensively used. At Valserine, on the Rhône, a canal has been cut through the rock, a third of a mile in length, thus giving a fall of about 12 metres and many hundred horse-power, using Jonval turbines. It is proposed to use the falls at Bellegarde, near Geneva, in the same way. The Manville Cotton Company, at Albion, R.I., use turbines, with a fall of 5·4 metres, which takes the place of a steam engine of 800 horse-power, and economy is materially gained, although during the five months of the dry season they are obliged to use steam. At the Pittsburg Mill, Minneapolis, there is a Victor turbine, working up to 1,400 horse-power, and another is being added of the same dimensions. These are only a few examples to show how thoroughly practical, economical, and convenient the use of turbines has become. We can, with them, calculate on utilising 75 per cent. of the theoretical power of the head of water. They can be controlled with the utmost ease. Their cost is very small compared with water-wheels, and they can be geared directly on to the shafts of dynamos. As an example of their adaptability to the purposes of the electrician, I may mention the performance of a Fourneyron turbine established at St. Blaise in the Black Forest, which utilises a fall of 108 metres, turns at a speed of 2,300 revolutions a minute, and gives off 60 horse-power.

The engineering works which would be required on the Severn would be very simple, though on a large scale, and the action could be made quite continuous, independently of the state of the tide, and without any necessity of using accumulators.

(TO BE CONTINUED.)

A CYCLONE.—A cyclone which swept through the States of Illinois and Wisconsin, on Friday and Saturday last, is described as "an enormous funnel, five hundred feet high, around the top of which the lightning played."

ELECTRIC LIGHTING OF LEEDS.

Particulars to accompany plans relating to the proposed lighting by electricity of portions of the municipal buildings at Leeds for the Corporation.

The Electric Lighting Committee of the Corporation of Leeds are prepared to receive tenders for lighting by electricity the following places, namely :—In the Town Hall : (1) The Victoria Hall. (2) The vestibule. In the New Municipal Buildings : (3) The vestibule. (4) The general pay office. (5) The gas and water clerk's office. (6) The general reading room—library division. (7) The lending library. (8) The reference library—lower level. (9) The reference library—upper level. Outside lighting : (10) In front of the Town Hall.—Victoria-square : (11) In Calverley-street.

The committee desire it to be distinctly understood by persons who may be prepared to tender that the positions indicated on the plans for the incandescent lamps and pendants, and the number of lamps mentioned as being considered sufficient to efficiently light the places named, are suggestions only on the part of the committee, and are given with a view to the tenders being prepared upon a common basis. Persons tendering are at liberty to suggest any probable improvement, either as regards the proposed position or number of the lamps, or with reference generally to the proposed scheme of lighting. If any departure is made from the character of the installation, as herein suggested, the tenders should be in an alternative form, namely :—1st, To cover the cost of the lighting as suggested by the committee ; and, 2nd, to cover the cost of any alternative scheme of lighting proposed in the tender.

PARTICULARS.

1. THE VICTORIA HALL.—The Victoria Hall in the Town Hall is 130ft. long, 71ft. wide, and 72ft. 3in. high. It is at present lighted by sunlights, containing 800 burners, of No. 3 size. The room is used for public meetings, festivals, concerts, balls, banquets, soirees, bazaars, panoramas, and similar purposes. The committee direct attention to the position of the grand organ at the north end of the hall, and to the form and area of the orchestra, which, upon special occasions, is often occupied by a large body of singers and instrumentalists. This circumstance may suggest the desirability of a slight increase in the quantity of light in the neighbourhood of the orchestra. For the present, the space underneath the gallery will not require to be lighted. Incandescent lamps must be used for the lighting of the Victoria Hall. It is suggested that 500 20 candle-power lamps should be employed for this purpose. The lamps may be distributed in such a manner as may be considered most conducive to the brilliant illumination of the hall, and as will best harmonise with its architectural proportions and ornamentation. If it should be proposed to suspend chandeliers or coronæ from the roof of the hall, sufficient and convenient means of doing so is afforded by the character of the double roof. The present sunlights are fitted with raising and lowering gear. The corporation are in possession of several of the large chandeliers recently hung in the Victoria Hall, the brilliant lustres belonging to which, it has been suggested, might be utilised in connection with the proposed lighting. One of these chandeliers has been fixed in the Town Hall, and may be seen on application to Mr. Linsley, the superintendent. It may be mentioned that the receptacles in the arches, near the roof, at each side of the hall, to which the main pipes of the ten chandeliers were lately affixed, are still available for use.

2. THE VESTIBULE, TOWN HALL.—One arc lamp of 1,000 estimated candle-power to be suspended from the dome in the vestibule, and proper raising and lowering year provided.

THE MUNICIPAL BUILDINGS.

3. THE VESTIBULE.—One arc lamp of 1,000 estimated candle-power to be suspended from the roof, and to be provided with proper raising and lowering gear.

4. THE GENERAL PAY OFFICE.—PLAN NO. 1.—This office will be used for the purpose of receiving rates and rents. The plan indicates the intended position of the pay counter and of the seven desks for the clerks. Plan No. 2 gives the section. Suitable raising and lowering gear to be provided. Four arc lamps of 1,000 estimated candle-power to be emyloyed in the lighting of this and the adjoining office.

5. THE GAS AND WATER OFFICE.—PLAN 3.—The clerks engaged in the work of the gas and water departments will be located at the five desks in this room, and it is suggested that two of the four arc lamps before referred to will be amply sufficient to light the room. Suitable raising and lowering gear to be provided. Plan No. 3 gives the section.

6. THE GENERAL READING ROOM.—PLAN NO. 4.—This plan shows the general arrangement of the tables and stands in the general reading room. The parts marked "A" indicate the intended positions of the newspaper stands, and the parts marked "B" indicate the positions of the reading tables. This department must be lighted with incandescent lamps, of which fifty-one may be employed, arranged in such manner as may be considered most likely to produce a successful result. The three red circles on the plan indicate the positions which may be found most convenient for pendants to each of which six lamps may be attached. The remainder of the lamps (three-three) may be distributed in groups of three each by pendants in the positions indicated by the cross in red on the plan.

7. THE LENDING LIBRARY.—PLAN NO. 5.—The public will resort to this portion of the free public library for the purpose of borrowing and returning books. The plan shows the intended position of counters, bookcases, indicators, and recesses. The "indicators" are frames 4ft. high, standing upon the counters, in the positions marked upon the plan, and show, by a small numbered tablet, whether a book is "in" or "out." One of these "indicators" may be seen at the Free Public Library, in Infirmary-street, Leeds. Incandescent lamps must be used for the lighting of this department. The places marked "Xa" on the plan show the suggested position of pendants in groups of two lamps each. It will be seen, on reference to the plan, that the areas of the spaces so marked are only small. The total number of lamps suggested to be employed in the lighting of this room will be seventy.

8. THE REFERENCE LIBRARY, LOWER LEVEL.—PLAN NO. 6.—This

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plan shows the intended arrangement of the counters, book-cases, tables and recesses in the reference department of the library. The parts marked "a" are tables or counters, to be used for purposes of reference to books, and the parts marked "b" are writing tables. Incandescent lamps must be used for the lighting of this department. The places marked "Xc" show the suggested position of pendant lights, also in groups of two. The total number of lamps proposed to be used in this room will be sixty.

9. The Reference Library, Upper Level.—Plan No. 7.—This plan shows the proposed arrangement of bookcases, writing tables, and recesses. Incandescent lamps must be used for the lighting of this department. The places marked "b" indicate the positions of the writing tables, and the places marked "Xc" indicate the suggested position of pendant lights, also in groups of two each. The red circles on the plan mark the suggested position of clusters of twenty lamps each, *i.e.*, forty in all. Round the space marked "open well," short standards, with two lamps each, sixteen altogether, should be placed, to light the sloping stands which it is intended to place there. The total number of incandescent lamps to be used in this room will be eighty. Plans 8 and 9 show a section through the library division of the building, and illustrate the area to be lighted in the general reading room, the lending library, the reference library, and the upper reference library.

Outside Lighting.—Four arc lamps to be placed outside and in front of the Town Hall. The present standards may be utilised.

In Calverley Street.—One arc lamp to be placed at the Calverley-street entrance to the Town Hall between the two existing gas standards, which may be utilised for supporting the framework of the lamp.

Engines.—The committee propose, at their own expense, to provide suitable engines and boilers necessary for driving the dynamo-machines to be used in connection with any of the tenders they may accept. Each tender must, therefore, contain an estimate of the horse-power required, also a statement of any special matters relating to plant, &c., other than which must also state the means to be adopted to reduce or extinguish any one or more of the lights in any part or section of the system.

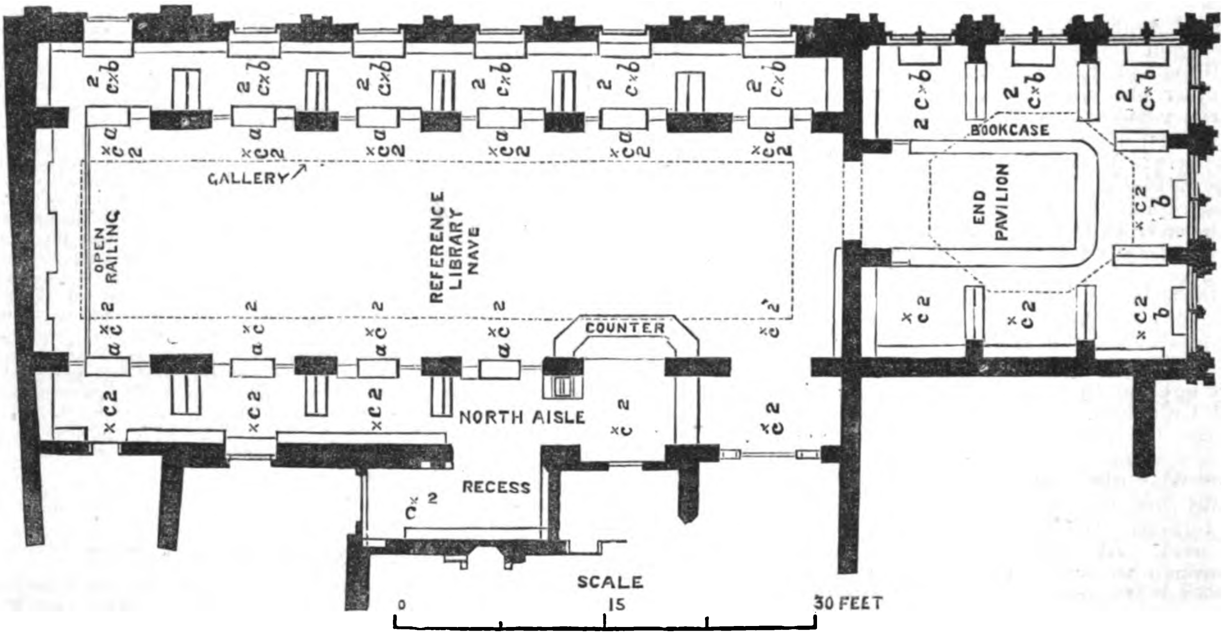
Fire Risks.—The tenders must state what means it is proposed to adopt to obviate the risk of fire from overheating, also if it is intended to carry out the requirements of the insurance companies, as contained in the recommendation of the council of the Society of Telegraph Engineers and Electricians, dated June 21st, 1882, in connection with such risks.

Fittings.—A short description of the fittings to be used must accompany each tender, and if it is proprosed to use shades with any of the incandescent lamps, it would be desirable to forward a sample shade with the tender. All wires must be carried to the various groups of lamps by means of wood mouldings, to harmonise with the walls and mouldings of the ceilings, &c., so as to cover up and preserve the wires.

Incandescent Lamps.—"Swan" or other approved lamps of not less than 20 candle-power must be used. The committee will, however, reserve to themselves the right to accept or require to have employed any other description of incandescent lamp of the same candle-power in connection with the proposed installation.

Arc Lamps.—The tenders must state if the person or company tendering are prepared to use, in the proposed arc lightning, any of the arc lamps now before the public, should the corporation desire, for experimental purposes, to make a selection therefrom. It would be desirable, also, if the tenders contained a list of the arc lamps any of which might be used in the proposed lighting, together with any suggestions as to their special suitability for either interior or exterior illumination.

Work and Labour.—The committee will open such parts of the public highways as may be necessary for receiving the receptacles for the conductors, and after the same have been laid therein will fill up and make good the trench. The committee will not, however, accept any responsibility in connection with the laying of the receptacles or cables, but the same and the necessary joint boxes shall be laid by and at the expense of the con-



Plan No. 6, showing the Library, &c., in the Leeds Municipal Buildings, to be lighted by Electricity.

the engines and boilers which the contractor would prefer should be provided by the corporation in connection with this branch of the tender. The contractor must provide and maintain all necessary belting and counter-shafting. Any person or company submitting a tender, who may themselves prefer to provide the whole of the plant and machinery necessary for the complete installation (including engine and boilers), may propose to do so, but are requested to include such items in a supplemental tender showing the additional estimated cost of providing such engines and boilers, &c.

The Power and Dynamo-Station.—The committee propose, at their own cost, to provide, within a distance of 400 yards from, but as near as possible to the Town Hall, a suitable building or place for the engines, boilers, and dynamo-machines, and will, in case the committee should provide the engines and boilers, make all necessary foundations for, and properly fix the boilers and engines ready for starting, after which the power will be delivered to the control, care, and maintenance of the contractors. At the end of the term, or on other sooner determination of the contract, the contractor shall re-deliver the engines and boilers to the corporation in good order and condition, reasonable wear and tear only excepted. The committee will, at their own cost, find and provide the gas, coal, and water, for the agreed term, and will also pay all rates and taxes on the station. The contractor must provide the necessary oil, waste, and petty stores.

Dynamo-Machines.—The tenders must provide for the employment of the Crompton-Bürgin dynamo-machines, for both the arc and incandescent lamp lighting.

Conductors and Leading Wires.—Perfect insulation must be adopted, and each tender must state the character and quality of the conductors and of the leading and connecting wires to be used.

Regulating Apparatus and other Fittings.—A list of the regulating apparatus and other electrical fittings must accompany each tender, tractor. The corporation will at their own cost supply a sufficient quantity of 3-in. iron pipes for containing cables. The contractor shall find and provide (with the exception herein otherwise proposed) all necessary plant and machinery for providing a complete system of electric lighting in the rooms and at the places named, and the whole of the work is to be finished in a workmanlike manner to the satisfaction of the electric lighting committee of the corporation.

The Working of the Plant.—The contractor will be required to place in charge of the installation a competent person or persons to work and carry out the lighting, during the continuance of the contract, the wages of such persons to be separately estimated in the tenders, and to be paid by the corporation. A weekly return shall be made to the committee and to the contractors of the full and complete details of the cost and working of the installation during the preceding week. The committee will reserve to themselves the right to suspend any workman employed by the contractor in or about the installation in the event of such workman not discharging his duties to the satisfaction of the committee, or who may conduct himself improperly, and to require the contractor to immediately replace the workman so suspended by another workman to be approved by the committee.

SUMMARY OF LAMPS.

Incandescent Lamps 20 C.-P.

	Proposed.
1 Victoria Hall	500
6 General Reading Room	51
7 Lending Library	70
8 Reference Library (Lower Level)	60
9 Reference Library (Upper Level)	80
Total	761

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ARC LAMPS.

	Proposed.
2 Vestibule, Town Hall	1
3 Vestibule, Municipal Building	1
4 General Pay Office	2
5 Clerk's Office	2
In front of Town Hall	4
In Calverley-street	1
Total	11

MAINTAINENCE AND CONTINUATION OF CONTRACT.—The tenders may be for a period of one or two years, and must be in the following alternative form :—1. The total amount for carrying out the whole of the electric lighting mentioned in these particulars, and for maintaining the same in an efficient manner for a period of twelve months from the completion of the installation, the whole of the plant and machinery supplied by the contractor to be removed by the contractor at the end of that term. 2. The additional amount at which the corporation may purchase, at the end of the first year, the whole of the plant and machinery so supplied by the contractor. 3. The total amount for carrying out the same work for a period of two years, the same plant and machinery to be removed by the contractor at the end of the term. 4. The additional amount at which the corporation may purchase, at the end of the second year, the whole of the plant and machinery so supplied by the contractor.

TENDERS.—The Electric Lighting Committee or the corporation do not bind themselves to accept the lowest or any of the tenders. The company or person whose tender may be accepted will be required to enter into a contract, to be prepared by the solicitor to the corporation, to complete the whole of the before-mentioned work within two months from the date of the acceptance of the tender by the committee, such contract to contain such clauses and conditions as may be necessary for carrying the same into effect, and particularly a clause empowering the corporation to determine the contract in the event of the contractor having failed, for a period of one month after the completion of the installation, to have efficiently carried out the terms of the contract during such month; and also a condition for the payment by the contractor to the corporation of a sum of £10 for each and every day during which default is made in completing the installation after the above-named two months.

The Victoria Hall and the vestibule may be inspected on application to the superintendent, and the interior of the new municipal buildings, may be seen on application to the clerk of the works. Sealed tenders and specifications, addressed to the Chairman of the Electric Lighting Committee, Town Hall, Leeds, and marked "Tender for Electric Lighting," to be delivered at the office of the Town Clerk, Town Hall, Leeds, not later than 5 p.m. on Thursday, the 21st June next.

By order of the Electric Lighting Committee,

GEORGE W. MORRISON, Town Clerk.

Town Hall, Leeds, 21st May, 1883.

THE WEST INDIA AND PANAMA TELEGRAPH COMPANY (LIMITED).

The twelfth ordinary general meeting of this Company was held on Wednesday, at the Cannon-street Hotel, Mr. C. W. Earle in the chair.

Mr. R. T. BROWN (the secretary) read the notice convening the meeting, and the report of the directors was taken as read.

The CHAIRMAN said : As far as the accounts go there is very little for me to remark upon them. They are very much the same as they usually are. I shall be very glad to answer any question that anybody may like to put upon them when I conclude. The only feature about them is one that is never absent from our report, which is the lamentable deficiency of revenue. To think that with 4,000 miles of cable, working twenty-one stations in the tropics, we should only be able in the course of the half year to carry traffic for which we receive about £25,000 is something quite unparalleled in the history of telegraph enterprise. It is not to be wondered at when I tell you that at some of those stations we have only three people who use the telegraph, and yet there is a proportionate mileage of cable, there are the ships and other expenses maintained for the benefit of those gentlemen who occasionally use our telegraph. It is therefore not to be wondered at that the revenue is a very poor one. But the question will then arise, How is it that so much capital is invested in such an unprofitable field as this? Well, I think, gentlemen, the answer to that is contained in a document which I hold in my hands. I do not go with those who always criticise the estimate made in a prospectus; they are generally put forth by people in sanguine moments and in hopes that what they state will be fulfilled, but when it comes with a certain amount of responsible authority, as this prospectus certainly did, it has a different complexion to my mind altogether. Now, I will just read to you what is stated in the original prospectus of this Company: "Sir Charles Bright, who has recently returned from the West Indies, has made a report upon the probable revenue to be derived from the Company's lines. This report, prepared from estimates based upon official returns, and the actual results of the existing Cuba line—earning after eighteen months working at the rate of £60,000 a year—fixes the probable receipts from messages on the Company's lines at £156,000 a year, and the working expenses at £20,000 a year." Well, this £156,000 was estimated as our traffic from fewer stations than we serve at present, because other stations were added almost immediately after the formation of the Company, at the earnest desire of other colonies that were not included in the enterprise. But then who were the gentlemen that endorsed this? Well, in looking at the names of the directors I find they are persons of the very highest standing in the West Indian trade and West Indian connections. I think that out of the whole number there are four gentlemen who are intimately connected with the West Indian business. Well, therefore, I think, to a great extent, the West Indies are responsible for the mistake, and it is nothing more than a mistake. Those gentlemen, no doubt, were actuated by the best intentions; they were men of the highest integrity, and believed what they stated, and endorsed this thinking they would have a revenue something like what they put forward. Well, it has turned out a most lamentable disappointment. No doubt the colonies are very much indebted to them for having obtained the capital; they afforded to them very great facilities, they have enabled them to economise for administrative purposes, and the telegraph has been of very great value to the home Government, besides being of very great value to the colonial Governments, and to every merchant carrying on business in those colonies. Well, seeing the manner in which this Company was raised, and the unfortunate result and disappointment as to traffic, I think, as our report says, that there is a certain amount of moral claim on the West Indies for the reconsideration of this contract—the most onerous contract ever entered into by any telegraph company—and for that purpose we have from time to time opened negotiations with them. We have sent out three missions to the West Indies, and I am sorry to say the result has led to very little improvement in our position. It would be a very difficult thing, as you may well suppose, to negotiate with a dozen separate Governments, and when you have brought them most into a favourable view you are thrown over by a final negotiation by one Government which is recalcitrant and obstinate on the subject. The mission sent out with Mr. Grosvenor was followed by a telegraph conference. We hoped that this conference would have looked into the question and seen if there was anything for this Company to live upon, and if there were any means by which the position of the Company could be improved to make it more effectual, and its cables made to carry on the business more to their satisfaction than they did. Well, the conference met, and did not inquire into the position of the Company in the least, but propounded a scheme for laying a cable direct to Bermuda and Nova Scotia. That scheme was submitted to the home Government, and after some delay, owing to reference to the Treasury and Postmaster-General, a report, a very exhaustive report, was issued by the Post Office engineer to the Postal Department upon the West Indian question altogether. It is a very exhaustive report, but there are one or two passages which I should like, with your permission, to read. In the Postmaster-General's letter he says, "Undoubtedly the Company have had great difficulties to contend with, but Mr. Fawcett believes that the present Board are striving to put their property on a sound basis, and notwithstanding the opinion expressed by the conference that the Company have failed to meet the requirements of the West Indian Colonies, he fears that there would be just cause for complaint against Her Majesty's Government if it were now to subsidise a rival company [they asked for subsidies, and intended to subsidise a rival company] especially as such a company would in all probability require not much less support in the shape of subsidies than the present Company lay claim to, and he directs me to observe that he thinks any company would have reasonable ground for objecting to supply the bulletin of news which the Company are called upon to furnish free of charge. No such information is supplied gratis by the other cable companies; it is given in the interests of a class, and the Company must in consequence lose a number of messages that merchants themselves would otherwise have to send." Again he says, "In conclusion, Mr. Fawcett would draw the special attention of the Lords Commissioners of Her Majesty's Treasury to the opinion of the engineer-in-chief to this department that any cables laid under the auspices of a new company would practically not be safer than those of the existing company, and would urge the greatest caution before any support is given to a scheme involving so much risk. It will be seen that in some parts the depth of the sea is enormous, and that the recovery of a cable, if interrupted at such a depth, is problematical; and he would point to the fact that as large a sum as £90,000 has been spent by one of the existing Atlantic cable companies in effecting the repair of a cable lying in a less depth of water." Then I will read to you—it will not take long—the concluding paragraph of the engineer-in-chief. It is a longish report that he gives upon the whole question, but the concluding paragraph seems to me to be important to us, it is all important, but that is particularly important: "Nor is it apparent to me that new cables laid under the auspices of a new company would in practice be any safer than those of the existing West India and Panama Company. They will be liable to the same dangers, resting on the same bottom, be subject to the same difficulties, or impossibilities of recovery, and generally be in no better position, excepting, perhaps, that the new undertakers may be supposed to be pecuniarily stronger, and therefore better able to cope with the difficulties of the position. When the West India and Panama cables were laid there was a want of care displayed by the speculators, the best positions for cables were not sought for, and it is only fair to add that in many cases no sufficient soundings existed for their guidance. Many of the errors then committed have since been rectified, but the Company has grown poorer and poorer, and want of means has prohibited renewal when necessary, or the laying of new cables when evidently desirable. I cannot but think, therefore, that in some fashion or other an improvement of existing means ought to be possible in preference to incurring a great and uncertain outlay for the purpose of partly doing that which, in theory at least, is now done much more fully, exposing the colonies to a total loss of communication to certain quarters, giving them no greater certainty than at present of the maintenance of their communication with Great Britain, and benefiting them only by a probably lower tariff, and the possibility that, for some time at least, the new concern will be financially stronger than the present one. Possibly, also, it is fair to say that the new cable might be expected to be of higher quality than the old, seeing the circumstances under which the latter was made, as well as laid; but what the islands have suffered from has been entire interruption, not from loss of insulation or imperfection of working." Well, gentlemen, those papers, and a great deal else which I could not take up your time in reading now, I felt were very satisfactory to us, because they really do state, in as fair a way as you can expect from official papers of that sort, what we have suffered from, and how little hope there was of the West Indies or anybody else to take our place. However, we felt that it was fair to us, and to the colonies, and to every one concerned, that we should lay before the Secretary of State for the Colonies our views as to what could be done if we have sufficient support. The interruption to our cables is an annoyance, no doubt, to the colonists, and naturally so. Every cable is liable to be interrupted, and ours particularly so; the ground is so bad, and we thought if they chose to pay for it we could lay a new line, which would give additional strength to the whole system. We then had an interview with Lord Derby, in which he, in a business

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like way, discussed the whole thing. I think he saw that we had a great deal to complain of, and that we had been rather unfairly treated all the way through. We all know the difficulties a minister has to get money; he is on delicate ground when he touches the finances of the colonies, he has no power to say you shall provide proper funds, and the exigencies of the Government in England make it a very difficult thing to help us out of the Imperial Exchequer. We all know with regard to the Cape cable it required a Zulu war and certain disasters to urge the Government to come forward and give a subsidy, which induced the subscription for the great work. But I must mention that while all this has been going on these very colonies whose representatives propounded such a magnificent scheme as the Bermuda and Nova Scotia line are in such financial difficulties themselves that commissioners have been sent out to inquire into the position of their finances, and Lord Derby has intimated to us that if we are corresponding with the colonies on the proposals submitted to him he must wait till he sees these commissioners, who returned the other day from their visit to those colonies, where they have been investigating the position of the colonies, which are in a very embarrassed condition. Therefore, there is nothing for it but to leave the matter in that position. I do not know that it is a very hopeful one, but still we have done all we can in the matter. We are entirely at the mercy of the colonies and the Government, who should see that if they do not help us they will have to go without the telegraph. If they do not see it in that light we cannot do anything more. We have petitioned them, and pressed the matter on them, and we must leave it to their judgment and decision, and sense of honesty I may say, as to whether they will support us or not. The appropriation of the balance is one that I daresay will cause some inquiry in your minds. The putting of an unusually large sum to reserve has, I believe, in the minds of some shareholders excited some question and anxiety, but the fact is that we must be the judges of the position as regards the prospects of the future. We have no right to divide what is really not earned, and seeing the very small amount of our reserve and this year we get a sum as a windfall out of the hire of our ship—we thought it was our duty to put such a sum as we have put, £15,000, to reserve fund. It is our first duty to maintain the system, whatever happens, and hard though it is - and I feel it very much for you and myself also, for I have a considerable stake in the thing—hard as it is, that we should have to set aside a reserve in order to provide all those gentlemen who are employing your telegraph with security of communication, I do not see myself we can help it at the present juncture. One of our cables has never been in operation since the present Board took office, the Jamaica San-Juan; it was laid at the origin of the Company, and we have never had time to repair that cable, and the condition it is in is very problematical. We have a ship working at it now, but we think, taking all these things into consideration, £15,000 is a wise appropriation at the present moment. On the 30th June, 188?, we placed £10,000 to reserve, and carried forward £5,840, and divided nothing, so that our action in this matter is not so abnormal as it would appear, because, as I said before, a considerable sum of this is a windfall which we cannot expect every day. If any gentleman wishes to ask any questions, I shall be very glad to answer them, and, in the meantime, I will propose that the directors' report and accounts to 31st December, 1882, submitted to this meeting, be, and the same are, hereby received and adopted.

Mr. W. FORD seconded the motion.

Some discussion ensued, and

The CHAIRMAN, in reply to questions, said that the expenditure was kept down to the lowest possible point, but it was absolutely necessary to keep two repairing ships, as one could not keep pace with the repairs, and it was found to be more economical, as the subsidies ceased directly there was an interruption.

The report was then adopted, and the retiring directors and auditors having been re-elected,

A vote of thanks to the chairman and directors terminated the proceedings.

THE CONSOLIDATED TELEPHONE CONSTRUCTION AND MAINTENANCE COMPANY (LIMITED).

Report to be presented at the second general meeting, to be held at the Cannon-street Hotel, on Thursday, May 31, 1883, at 12 noon. The directors beg to lay before the shareholders a statement of accounts and balance-sheet for the year ending March 31, 1883. The directors do not recommend the payment of any further dividend for the past year, the operations of which have in many respects been very disappointing. The accounts show scarcely any transactions with the United Telephone Company. It is not expedient to detail the causes of difference between the two companies, because, since the expiration of the financial year, a satisfactory arrangement has been come to between the two companies, covering a settlement for the past and future relations. The directors are glad to be able to say that in connection with this settlement the United Telephone Company have relinquished to the Consolidated Telephone Company the benefits of an important agreement which the former company has entered into for supplying telephones to the Post Office. In order to extend the Company's business the directors entered into engagements in relation to telephone concessions in Austria, of which they entertain a high opinion, and some of which are already in active operation. The directors also regard most favourably the interests which the Company has in the River Plate Telephone Company. Probably few telephone companies have a better future before them than the River Plate Company. Embarrassed from want of capital, and with the danger before them of possibly having in consequence to sacrifice valuable interests, the directors had to determine to dispose of some of the unissued shares, and the market value left them no option but to do so at a discount. The financial difficulty is now surmounted; but the directors do not think it desirable to divide at present the money that is to be received from the United Telephone Company. When, as it is shortly proposed to do, the Austrian concessions are placed on a separate footing, a further division of profits will be fairly a matter for consideration. A considerable number of instruments are being sent to Australia, India, Egypt, and other parts of the world, under arrangements with the Oriental Telephone Company. The auditors, Messrs. Deloitte, Dever, and Co., retire in pursuance with the Articles of Association, but are eligible for re-election.

ELECTRIC SUN LAMP AND POWER COMPANY.

The ordinary general meeting of this Company was held at the City Terminus Hotel, Cannon-street, on Wednesday; the Right Hon. Lord BRABOURNE in the chair.

Mr. J. REEVE (the secretary) having read the notice convening the meeting, the report was taken as read.

The CHAIRMAN expressed regret that the meeting had been fixed for what had transpired to be the Derby Day, a circumstance of which the directors were ignorant at the time of fixing the meeting owing to their want of racing knowledge. The shareholders would hardly need an apology from him on the part of the Board for having called them together at such an early period. As the statutory meeting of the Company was held at the end of October last, the directors were under no obligation to call the shareholders together until the end of the present year; but they thought it was very desirable, under existing circumstances, that they should meet at this particular time, so that the shareholders might be informed as fully as possible of the position of the Company. After referring to his absence, owing to ill-health, both at the time of allotment of the shares and from the statutory meeting, and observing that the allotment was only proceeded with when the conditions previously decided upon by the Board had been fulfilled, he stated that they had not at the date of the allotment, nor had they at the present moment, any doubt whatever of the ultimate and entire success of the Company. At the statutory meeting Sir James Carmichael (the deputy-chairman) clearly laid before them the position of the Company. Before he (Lord Brabourne) allowed his name to be connected with this enterprise he made every possible inquiry, and satisfied himself, as far as any man not possessed of special knowledge of electricity could satisfy himself, that the Sun lamp was likely to be a great success—an opinion which was not only his but that of others who had seen the manner in which the vaults beneath the Exchange were lighted last year; and that was also the deliberate opinion of men who had made electricity their study and its development their profession. He felt bound to add that up to that moment they had had no reason to recede from that opinion. It might be asked, why, if their lamp was so good, had it not been more fully exhibited, as other electric lamps had been? The answer to that question was, that in pursuance of the policy which the directors had decided upon, they felt that such a good lamp would push its own way, slowly, perhaps, but surely, without wasting money in unremunerative lighting or sensational exhibitions. Considering that electricity was, in a manner, in its infancy, it had also been their endeavour to make the lamp as perfect as possible, and to adopt such improvements as they had suggested from the first, and which had now been carried out by the inventor, rather than to hurry it prematurely before the public. Their object had been to lay the foundation of future success on such a firm basis that when the fabric had once been erected there should be no chance of its overthrow. They had not, however, been idle, but they had pushed the enterprise legitimately and judiciously forward in every way. They had done this both in London and in the country, where they had been quietly laying the foundation of an extended connection, and in the hope that when success began to develop itself, as they believed it would, the progress of that success would be large and rapid. He then referred to the appointment of a managing director, whose business it was to inspect closely the details as to the machinery, as to the manufacture of the lamps, and the installations in the actual every day working of the Company. They had been exceptionally fortunate in securing for this office Mr. Bartley, who had most assiduously attended to the daily business connected with the manufacture of their lamp and its introduction into the world, and he felt it would be better to leave to him any explanation as to the details which the shareholders might require. The Board had endeavoured to work for the interests of the shareholders both in London and in the country. The principle upon which they had worked in the country had not yet been fully tested, for a sufficient time had not yet been given for its development; but they had the greatest confidence that in a short time they would be able to show the results of the country installations in such a manner as to fully justify the policy of the Board in that direction. The total expenses of the country installations had, however, been under £800, a considerable proportion of which still belonged to the Company in the shape of plant. With regard to the London work, he did not wish to conceal from them for a moment that it was in London that the question of their success would be tested and decided. With this prospect in view they had secured eligible premises in Riding House-street, where he believed the exhibition of electric lighting by their lamps on the previous evening gave entire satisfaction. They had, moreover, obtained the approval and support of two vestries in their application to the Board of Trade for licenses, and if those licenses were granted on the terms which they hoped they would be, he did not think there could be any doubt as to the success of the Company. Upon that their success very much hinged. The directors were as anxious as any of the shareholders for a dividend; but, at the same time, the dividend must be earned before it could be satisfactorily declared. It was to be remembered that when money was subscribed for the construction of a railway, until the line was completed, the rails laid, the sanction of the Government inspectors obtained, the line opened, and the traffic operations in full swing, they could not pretend to hope for a dividend; and similar remarks applied to an undertaking such as that in which this Company was interested. There must be a great deal of expenditure not immediately remunerative—he said "not immediately remunerative," because all expenditure judiciously directed became in the end remunerative if the Company was a success. If he were right in his premises he thought the shareholders of this Company might take a great deal of comfort to themselves by remembering the difficulties which were met with by those interested in gas on its introduction, and then thinking of the handsome dividends which were now being paid by the gas companies. If scientific men were right in prophesying for electricity the success which they had predicted for it, he did not see why in a few years time they should not be able to forget their present unremunerative expenditure in the dividends they would then be receiving. At the same time they must not shut their eyes to the difficulties before them, and must recollect that a dividend could not be expected before a sufficient time had elapsed for the development of their enterprise. It was not to be forgotten that since this Company was founded the Electric Lighting Bill had been passed, and that this had placed certain restrictions on them. He did not think they need apprehend that anything in the rules and regulations of the Board of

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Trade would be unfair or unjust; but until they knew positively what those rules and regulations were, and knew upon what terms they would obtain the licenses for which they had applied, it was impossible to speak with such confidence of their future success as he hoped to be able to do when he next addressed them. The two vestries who had supported them were St. James's and Marylebone, and if the licenses applied for were granted on fair terms they would have before them a very large business—as much certainly as they could undertake with their present capital. There might be conditions imposed with regard to the depositing of money, and with regard to other matters, which might oblige them to hasten a call, or even to ask the approval of the shareholders to a further issue of capital. They did not know whether this would be so, but they must not shut their eyes to the possibility of such an event. Their expenditure had up to the present time, he contended, been wise and cautious. They had plenty of business before them only awaiting the licenses from the Board of Trade, and they had a large reserve of capital which would enable them to prosecute the enterprise, and go on, as he hoped, to promote satisfactorily the success of the undertaking. The policy of the directors would be to act with care and caution, but at the same time with courage, not to be afraid of obstacles, and not to be afraid to ask for more capital if they believed it would ultimately be productive of remunerative results, although they might have to wait a little time for them. He believed there were the elements of success in their light, and that in the manner in which they had dealt with it they had placed the shareholders in no difficulties, and with the expenditure of capital he had mentioned they had brought them up to this point—that if the licenses were granted on satisfactory terms—and there was no reason to suppose that the terms would not be satisfactory—they had a business waiting for them which must in a comparatively short time develop into a considerable state of prosperity. He would remind them that if they did not wish to go on with the enterprise they would sacrifice all the money they had expended—a proceeding which, as men of business, he did not believe they would entertain for a moment. In conclusion, the chairman moved the adoption of the report.

Mr. ROBERT MILBURN seconded the motion.

Mr. JONES asked how they were progressing with the preparations for lighting a portion of the South Kensington Museum?

Mr. BARTON suggested that it might be well to defer the consideration of the call until they knew whether the licenses were granted or not.

Mr. GEORGE C. T. BARTLEY (managing director), in reply, said they were going to light some of the picture galleries at the South Kensington Museum with forty lamps. As the shareholders might be aware, part of the museum was being lit by another system of arc lighting—the Brush—but this Company was going to light the Jones Bequest and four or five long galleries with forty lamps. They had been allotted premises and a place for engine power, and they would be paid the same price as was now being paid for gas—from £2,000 to £3,000 a year, the total gas bill for the museum being about £8,000 a year. They calculated that they would be able to carry out this lighting arrangement at a price which would leave them a profit of £100 or £150 a year; but if the thing were a success the museum authorities would be only too glad to let them light up other portions of the building. Indeed, they had already offered to let them do so, and if the station succeeded as well as they believed it would, and they lit up the whole of the museum, the result would be very profitable indeed to them, and the authorities might buy up the whole of the plant. With regard to the central station, that had been a great source of expenditure; but it had been necessary to have such a station to show their *bonâ fides*, and to show that they were not a merely speculative affair. At their station in Riding House-street they had been able to show their light on a sufficient scale to prove to the vestries that they were in earnest, and the vestries of St. James and Marylebone had so cordially supported their application for the licenses that he had no doubt that they would be granted. He had been to the Board of Trade several times, and he had found the authorities there perfectly in earnest, and as he had been able to show the *bonâ fides* of the Company he had no doubt the licenses applied for would be granted on very reasonable and proper terms. With regard to the country installations, the plan adopted had been to charge a small proportion of the cost—about the amount which those applying to them had been spending in gas, and at the end of the term fixed upon they either sold the plant or took it away. At Bradford they had been lighting up a portion of a very large iron works with entire satisfaction, and he believed that before long the whole of those works would be lit by them. This would, he had no doubt, be a very profitable source of income to the Company, as it would make their light known in an important centre. Careful experiments had been necessary to bring the lamp to its present state of perfection, and to enable each lamp to be turned on and off at pleasure. Great difficulty had been experienced in getting the things made which they required, and especially in obtaining dynamos; but they were now ready for their autumn campaign. In the North of Scotland their light had given the greatest satisfaction, and experiments were being made to make use of the water-power in the district. The people there had seen several other lamps; but theirs was the only one they would have at any price.

In reply to questions, Mr. BARTLEY added that the lease of the Riding House-street premises was thirty-five or thirty-six years. If they were to defer making a call until they had the Board of Trade licenses their works would be stopped, and everything would be at a standstill. Unfortunately, the Board of Trade were rather slow in their operations, and the Company were getting everything ready in view of their sanction. So confident was he that they would get the licences that he thought they ought not to wait, and it would be very inconvenient not to make a call, and shut up their place. The principal vestries had this sunlight. He hoped that the picture galleries at South Kensington would be lighted up in about three weeks. They would only have their large lamps there—1,000 to 1,500 candle-power. The museum authorities would regulate where they would put the lamps.

A SHAREHOLDER said that he had been informed by opponents that a greater amount of horse-power was required to work the sun lamp than any other.

Mr. BARTLEY stated that the Company's engineers, Messrs. Sabine, had gone into the matter very carefully. For his own part he must acknowledge that he was not sufficiently technical to be able to tell them exactly the horse-power that they proposed. As soon as their works were going in Riding House-street they were carefully to test this matter. Till that was done he would rather not commit himself, and it was a matter which could only be verified by a long series of experiments carried on in a scientific way. The station would be available for lighting private houses. The area they proposed lighting was a little over half a mile—from the Langham Hotel to Beak-street, and then across, not quite, to Wardour-street. The lighting at South Kensington was specially for the museum. They could introduce any ordinary incandescent lamp to work in conjunction with their own lamp on the same circuit. The only provincial installation which had run out had been at Wolverhampton, and that had not been as successful as they could wish. The fact was that the people there were very anxious to have the light all in a moment, and the Company were perhaps a little unwise in letting them have it before they were quite ready. The dynamo was not quite in order, and the lamp was not of the best type. Something had broken down, which was not a very satisfactory feature. That was the only place, however, where they had any difficulty. They had no doubt that at Bradford they would have a great success, as well as at Glasgow and other places. The experiment at Wolverhampton was tried for three or four months, but the firm which tried it had changed their business, and removed to another town, some 50 or 60 miles off, where they were not going to manufacture. The Company had enough capital to take the two districts they proposed lighting, but they could not further extend their system without an increase of capital. They had plenty of evidence that private people in their district would take the light if they could get it as they could get gas, and that was the object of the Company having the central station.

The CHAIRMAN, in further reply, stated that if they increased their capital it would be in consequence of the success of their working with their present capital, which would, therefore, be satisfactory. He thought that Mr. Bartley had fully shown the wisdom of not deferring the call. They had produced the results which he had intimated by means of half of their present subscribed capital, and he thought they could stand comparison with any other company which had come before the public in a similar manner. At the end of seven years the local authorities had the power to acquire their plant, paying them compensation which they must hope would be commensurate with the success achieved by the Company. The vendors had received all that they did receive in cash. There was a balance of £19,950 to be paid over in shares or in cash, and if not paid in cash by 31st December, they could compel the vendors to receive shares. The vendors had, however, shown such liberality towards them that they apprehended no difficulty with them.

On the motion of Mr. JONES a vote of thanks was passed to the chairman and the directors.

The CHAIRMAN briefly replied, and pointed out that the directors were as much interested as the general body of the shareholders in the success of the Company.

The proceedings then terminated.

THE MAXIM-WESTON ELECTRIC COMPANY (LIMITED)

The adjourned meeting of this Company was held on the 18th inst., at the Cannon-street Hotel, Admiral Sir E. A. Inglefield in the chair, for the purpose of receiving the resignation of the directors, and also confirming certain resolutions increasing the capital of the Company.

The SECRETARY (Mr. T. R. Comyn) having read the notice convening the meeting,

Mr. G. MANDER ALLENDER said that before commencing proceedings he wished to ask one or two questions. A circular had been issued to the shareholders from the office of the Company, Cannon-street, signed by Mr. Hugh Watt; that circular contained some positive assertions with regard to figures, and he wished to ask if it was an official circular.

The CHAIRMAN: No, it is not.

Mr. ALLENDER: Being dated from the office I thought it was.

The CHAIRMAN: I may say the Board of Directors as a body knew nothing of the circular. It was not sent to them. I only saw it accidentally by its being sent to me by a shareholder. The Board know nothing of it officially.

Mr. ALLENDER asked the chairman if he endorsed the figures given by Mr. Watt?

The CHAIRMAN: Most certainly not. If I could I should have been very faulty in not bringing the figures forward at the last meeting and saying we were making a profit at the rate of £10,000 a year.

Mr. ALLENDER would like to say, as a member of the late committee, he did not believe in the figures, and could not endorse them, and he challenged Mr. Watt to prove their correctness before a committee of shareholders of this Company. If Mr. Watt were right, then he was wrong, and he would ask Mr. Watt's pardon. If Mr. Watt were wrong it would be for those gentlemen who had supported him to ask themselves whether their proxies had not been obtained by unfair means.

Mr. WATT said that it was incorrect to suppose that he had obtained proxies on the circular he had issued. On the first occasion he held proxies for 30,000 shares. They were not used on that occasion. He held proxies now for over 50,000 shares, but those proxies were not secured by means of his circular. They were obtained chiefly at his own expense by personal canvass. What he asked the shareholders was, whether they wished to retain him on the Board? If they did not wish him to remain he wanted them to say so, as he had no desire to force his services on the Company. He contended that the figures in his circular were correct, provided all the production were sold, and that the profit would then be £200 a week.

The CHAIRMAN said the manufacture of an article and its sale were two different things. They had 10,000 Maxim lamps in their cellars, and were still making them. When they had a large number of lamps in store they must not reckon the profit on them until they were sold. He would now read a letter which he had received from Mr. De Kabath, a gentleman who represented the American company who sold to this Company the Maxim and Weston patents. The letter was dated the 15th inst., and in the course of it Mr. De Kabath stated:— "Answering your request for me to join the Board of the Maxim-Weston

Electric Company, I will say that I have no objection to join the Board with yourself as chairman, and such other parties as you have named to me already as members of the Board, and I feel certain that we will make as great a success of this business here in England as it is already in the United States, and, to some extent, on the Continent. . . . We have to-day, in New York alone, five central stations for the purpose of supplying light, each station is fitted with engines of 500 horse-power, and ample space to allow for the duplication of the plant. We have also installations in the principal buildings: to mention a few, the 'Equitable,' 'Hoffman House,' and about one hundred others. The company's works at Newark, New Jersey, cover a large area, and about one thousand men are employed: four dynamo machines are turned out daily, which forms a total of 1,200 dynamo machines alone per annum, and they have orders for sixty days ahead. The United States Electric Lighting Company paid to their shareholders last year a dividend of five per cent. on their shares, besides carrying over a large reserve. . . . Its sub-companies, the New York Illuminating Company, the New England Weston Company, the companies in Pittsburgh, Louisville, Chicago, Charlestown, and elsewhere, are doing equally well. Estimating roughly, as the business is steadily increasing all the time, I can say that there are not less than 20,000 Weston arc lights in actual daily operation throughout the United States, and not less than 50,000 Maxim incandescent lamps. I think these figures speak for themselves, and I need not add anything to their significance, but I must remark that the business in store for the United States Company is much larger than anything that could be to-day foretold. Messrs. Weston and Maxim are the ablest electricians living to-day. Mr. Weston is now actively engaged in bringing out a complete system for transmitting power by electricity. The experiments which I have witnessed myself were most conclusive. . . . Being myself the owner of some inventions and the representative in Europe of the Maxim and Weston systems of electric lighting, I must not presume to criticise other systems. . . . I must, however, say that having overcome all the difficulties we had to encounter, both in America and Europe, in my opinion there can be no doubt that these two systems, Maxim and Weston, are to-day the very best, both for incandescent and arc lighting. . . . The renewal of lamps forms an important item in working expenses, and the fact of its long life makes the Maxim lamp the most economical one. We have neither been idle on the Continent. The Compagnie d'Eclairage Electrique have purchased our patents for France. It might interest you to know that the price paid by that company for the French patents was very nearly the same as that paid by the English company for the English patents. The French company is now working two systems, viz.:—The Jablochkoff for arc lights, and the Maxim for incandescents; they own also the Weston system, but could not work it, as the French law makes it obligatory to manufacture the apparatus in France. We have been most successful also in Spain, where there are some 40 or 50 plants of our incandescent lamps in actual operation. In Austria, where this summer a large International Electric Exhibition takes place, we shall be well represented, the United States Electric Lighting Company having already forwarded the necessary machines and apparatus. I might mention also that in Vienna we are the only incandescent light system to be seen, having two plants in successful operation for the last six months. In Italy both our systems are well represented. One of our incandescent installations has been visited by the Royal Family, and the Duke d'Aosta expressed a desire to have our light in his palace. We shall be largely represented at the coronation of the Czar of Russia. We have also a great many plants in operation in Germany, Sweden, Norway, Denmark, Belgium, and Holland. To conclude, I will say that I am not of the opinion held by some gentlemen, that the present difficulty of the Maxim-Weston Company in London is to be solely attributed to bad management. I think that the great difficulty that this Company has had to encounter is insufficient capital. No manufacture can be fairly established without the means of establishing a factory, and it is also most essential to have ample funds for working expenses at the outset. This latter is a very important point with electric companies, as the capital must be laid out in plants, central stations, &c. We have up to the present been endeavouring to accomplish certain things which it was impossible to attain without the means necessary for their accomplishment. Can one imagine a gas company being started in London with a capital of £100,000 or £200,000? The capital of a company must correspond to the business it proposes to carry on. . . . . That electricity can be commercially employed is fully demonstrated by the United States Electric Lighting Company, and I have not the slightest doubt but that it can be similarly used in Great Britain if there are adequate means, and the business be conducted with the same amount of enterprise as it has been in the United States." Continuing, the chairman said that, on receipt of that letter, having obtained Mr. de Kabath's consent to nominate him on the Board, he sent in the paper to do so, as he thought in proper time, but unfortunately the letter which he sent in was, according to the Act of Parliament, a few hours late. He nominated also another gentleman, Mr. Allender, who was on the committee of investigation, and he thought that would be an excellent name to bring before the shareholders for election as a director; but unfortunately the same objection applied in this case also. He had therefore been obliged to seek some other way in which those gentlemen could be elected. They would ask the shareholders to elect certain directors today, and in addition two gentlemen, who, if elected, would be ready to retire afterwards, in order that their places might be filled up by the gentlemen whom he had named. With that he placed his own resignation in the hands of the shareholders.

Mr. INVERARITY said that there was no doubt that this was a crisis in the Company's affairs; but the Company was a good one. Their patents were excellent, and it only required a little more time and money and good management. He entirely endorsed what Mr. de Kabath had said. It was hardly fair to the directors at this early stage to accept their resignation, as it amounted to a vote of want of confidence in them. He proposed that the resignations of Admiral Sir E. A. Inglefield and of Mr. Swaby should not be accepted. They were both hard working men, whom he could recommend as directors, and he suggested that they should elect Mr. de Kabath and Mr. Allender as their colleagues. They should leave those gentlemen to settle any differences with Mr. Watt. He must, however, state that Mr. Watt had been of great service to the Company, and had saved it from many disasters.

Dr. THOMAS seconded the motion.

The CHAIRMAN said he had not the slightest wish to remain a director of this Company. He had worked at it for two years, and brought it to a certain point, and he believed it had nothing but success before it, but when gentlemen like Mr. de Kabath and Mr. Allender begged him to remain he gave way.

The motion not to accept the resignation of Admiral Inglefield was put separately, and carried with one dissentient.

It was also resolved unanimously that the resignations of Sir H. B. Sandford and Mr. L. Swaby should not be accepted. The resignation of Mr. Watt was rejected with a few dissentients.

Messrs. S. Gray and J. Brown were elected directors, on the understanding that they would retire for the appointment of Messrs. de Kabath and Allender.

The following resolutions, passed at the previous meeting, were then confirmed, viz.:—"That the nominal capital of the Company be increased by the addition thereto of 327,500 shares of £1 each beyond the registered capital of £172,500, in 172,500 shares of £1 each, making the total capital £500,000," and "That such 327,500 shares may be allotted at the discretion of the directors, on such terms and at such times as they think fit, and either at a premium or at a discount."

A vote of thanks to the chairman and directors then terminated the proceedings.

COMPANIES' SHARE LIST.

TELEGRAPHS.

Companies.	Closing Prices May 23.		Business Done Week Ending May 23. Highest.	Lowest.
Anglo American	50,	51	50½	50
Do. Preferred	81½,	82½	83	81½
Do. Deferred	19½,	20½	20¾	20
Brazil Submarine	12¼,	12¾	12⅝	12½
Cuba	10,	10½	10½	10½
Do. Preference	17,	18	17½	17½
Direct Spanish	6,	6½	6½	6½
Do. Preference	16,	16½	—	—
Direct United States Cable	12⅝,	12⅞	12⅞	12 11-16
Eastern Telegraph	10¾,	11	11	10¾
Do. 6 per Cent. Preference	13½,	13¾	13½	13½
Do. 5 per Cent. Debentures, 1899	104,	107	—	—
Eastern Extension	12,	12½	12½	12 1-16
German Union	10,	10½	10	10
Globe Telegraph and Trust Company.	7,	7½	7¼	7
Do. Preference	12⅞,	13⅛	13 1-16	12⅞
Great Northern	12¾,	13	12⅞	12¾
Indo-European	31½,	32½	32	32
Mediterranean Extension	1½,	2	1¾	1¾
Do. Preference	6,	7	—	—
Reuter's	9½,	10	9⅝	9⅝
Submarine	247,	252	249½	248¾
West India and Panama	1⅛,	1⅜	1 3-16	1 1-16
Do. 1st Preference	6¾,	7¼	7 1-16	6¾
Western Brazilian	6½,	6¾	6⅝	6⅝
West. Union 7 per Cent. 1st Mortgage	122,	124	—	—
Do. 6 per Cent. Sterling Bonds	103,	106	—	—

TELEPHONES.

Consol. Telephone and Maintenance	½,	¾	11-16	⅝
Oriental	½,	⅝	9-16	½
United Telephone	9,	9½	9 5-16	8¾

ELECTRIC LIGHT.

Anglo-American Brush Lgt. (£7 paid).	4½,	4¾	4⅝	3
Do. (fully paid)	7,	8	7	6
Hammond Light	2½,	3	2¾	2 7-16
Swan	1⅝,		1⅝	1¾
Maxim-Weston	⅛,	⅜	¼	3-16

TRAFFIC RECEIPTS FOR APRIL, 1883.

Companies.	April, 1883.	April, 1882.	Incrse.	Decrs.
Anglo-American Telegraph Company	—	—	—	—
Brazilian Submarine Company	—	—	—	—
Cuba Submarine Company	3,900	3,921	—	21
Direct United States Cable Company	—	—	—	—
Direct Spanish Telegraph Company	1,766	1,824	—	58
Eastern Telegraph Company	45,148	42,667	2,481	—
Eastern Extension Telegraph Company	32,005	29,269	2,736	—
Great Northern Telegraph Company	20,400	—	—	—
Submarine Telegraph Company	—	—	—	—
West Coast of America Telegraph Company	—	—	—	—
Western and Brazilian Telegraph Company	—	—	—	—

NUMBERS OF "THE ELECTRICIAN" OUT OF PRINT.—The following numbers of *The Electrician* are out of print, and cannot be supplied at the office, viz.:—Vol. 1, Nos. 3, 9, 19; Vol. 7, Nos. 8, 10, 12 to 18, 20, 21, 24 to 26; Vol. 8, 1, 3, 6 to 12, 15 to 26; Vol. 9, Nos. 2, 4, 24, 25; Vol. 10, No. 13.

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NOTES.

South America.—The cable between St. Elena and Payta is interrupted.

Birmingham.—The head telegraph office at Birmingham is to be enlarged.

Electric Light in Quebec.—It is stated that arrangements are being made for lighting the harbour of Quebec by electricity.

Brazilian Submarine Telegraph Company.—The traffic receipts of this company for the week ended the 25th ult. amounted to £2,919.

The Edison System in Queensland.—The Government printing office at Brisbane, Queensland, has been lighted with Edison's incandescent lamps.

Electric Light in Canada.—News from the Dominion states that the city of Hartford having tried a system of electric lighting on a limited scale, was about to utilise it to the fullest extent.

Business Notice.—Messrs. Walter T. Glover and Co., wire makers, of Manchester, inform us that they have opened offices at 85, Buchanan-street, Glasgow, under the charge of Mr. A. B. Spence.

Trinidad.—Recent news from this island stated that Mr. Gray, agent to the Tropical American Telephonic Company, had been in the colony with the object of establishing a telephonic exchange in the capital.

Telegraph Construction and Maintenance Company. —The Bill by which this company are going to extend their powers, so as to include electric lighting, &c., was read a third time in the House of Commons on Thursday, the 25th of May.

London Platino-Brazilian Telegraph Company.—The revenue of this company for the month of February is estimated at £2,115 (Western Brazilian portion £1,424, land lines £691), as against £2,227 for the corresponding period of 1882.

Western and Brazilian Telegraph Company.—The traffic receipts of this company for the week ending 25th May, 1883, were £1,931, after deducting the "fifth" of the gross receipts payable to the London Platino-Brazilian Telegraph Company.

Brooklyn Bridge.—This bridge, which unites New York and Brooklyn, has just been opened with great pomp. It is a wonderful piece of engineering enterprise. It is to be lighted by arc lamps, the United States Electric Light Company having obtained a contract for the work.

The Telephone in British Guiana.—The annual subscription to the proposed telephonic exchange in Georgetown has been fixed at 60 dollars, and it is feared that this rate will be held to be prohibitory to many persons who are desirous of becoming subscribers.—*Colonies and India.*

Electric Light on Ships.—The ss. "Adelaide," now finishing at Messrs. D. and W. Henderson and Company's yard, Partick, near Glasgow, is to be lighted throughout with the incandescent system. The work has been entrusted to the Edison Electric Light Company, who, with a single exception, have now in hand all the electric lighting on Clyde shipping.

The Fisheries Exhibition.—The entrance vestibule and the Fine Arts Gallery at this exhibition will be lighted by means of 350 Woodhouse and Rawson incandescent lamps, the necessary current being supplied by an Elphinstone-Vincent dynamo. We shall refer to the lighting of this exhibition at greater length when the arrangements are in a more complete state than they are at present.

Electric Light in California.—It is stated that the California Electric Light Company has made a proposition to replace 1,700 gas lamps of 16 candle-power, maintained at a cost of 77,350dols. per annum, in San Francisco, with 210 electric lamps, aggregating 420,000 candle-power, for the sum of 65,520dols. per annum. These lights are to be set upon 40ft. poles at the crossings of every alternate street.

Electric Light in Chemical Works.—The chemical works of Messrs. Barnes and Co., Hackney Wick, are now lighted by means of a Lumley dynamo and sixty 20 candle-power incandescent lamps, thus enabling work to be carried on day and night without intermission. Where combustible and explosive materials have to be handled, there can be no safer or better light than is afforded by the incandescent system.

Electric Lighting in Theatres.—Part of the Gaiety Theatre, London, is to be lit up with Swan lamps, the current being supplied by the Electric Storage Company's accumulators. The branch wires will be laid in Longden-Welch's patent grooved slate. The contract has been obtained by Mr. H. Bury, of 46, Market-street, Manchester, who, we believe, is also to light up the Princess's Theatre in that town.

Electric Light Towers.—One of the electric light towers, as they are called, which have been erected at Fairfield, Indiana, U.S., came down with a crash on the 9th of last month. The cause of the disaster was a heavy gale of wind. The tower was 175 feet high, and had six Brush lamps on it. In falling the tower carried away a considerable length of the telegraph wires belonging to the Western Union Company.

The Telephone for Collieries.—The Mitchells Main Colliery Co., near Barnsley, have adopted the telephone between their chief offices in Barnsley and the collieries near Wombwell, a distance of five miles. One of the lines is carried into the workings in order that the manager may speak from Barnsley direct into the pit. The Johnson-Bell telephones are used, and have been fixed by Messrs. Tasker, Sons and Co., of Sheffield.

The Telephone in the Provinces.—In our issue of May 5th we mentioned that telephonic communication was about to be established between Carlisle and Silloth, a distance of twenty-three miles, for Messrs. Maxwell and Sons, chemical manufacturers. The communication has since been completed with Johnson-Bell telephones, and the results are stated by the local press to be exceedingly satisfactory, notwithstanding that the wire is erected on the railway amongst the ordinary working wires.

Railway and Electrical Appliances Company.—Vice-Chancellor Bacon has made an order for the appointment of Mr. John Young, public accountant, London, as provisional liquidator of this company, whose works are at Glasgow. The petition for liquidation, which was heard last week, was presented by the Duke of Manchester and others, and it appeared that there were as many as seventy-five actions against the company by shareholders desiring to be relieved of their shares.

Electric Light in Factories.—One of the large spinning and weaving factories of the town of Bolbec (Seine Inferreure) belonging to Messrs. Lemaitre, Lavotte and Co., has been lighted for some months past by means of incan-

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descent lamps. The installation comprises 350 Swan lamps, fed by two Siemens alternate current machines with their exciters. A third is held in reserve, should one of the other two fail. The managers of the factory are so pleased with the new light that they have just ordered 165 new lamps. When these have been fitted up the whole of the work rooms will be lighted by means of electricity.—*L'Electricité.*

UNITED v. LONG DISTANCE TELEPHONE COMPANY.—On Friday, the 25th May, before Mr. Justice Chitty, the United Telephone Company moved for an interim injunction to restrain the defendants, until the trial of the action, from using, manufacturing, or selling instruments made according to Hopkins's patents, which they claimed to be infringements of the Bell and Edison patents. Mr. Aston, Q.C., and Mr. Moulton were for the plaintiffs; and Mr. Macnaghten, Q.C., and Mr. Davenport for the defendants. It was arranged between the parties that, without prejudice to any question in the action, the defendants should give an undertaking in the terms of the notice of motion, and the plaintiffs should give an undertaking in damages.

GLOBE LIGHTNING.—Dr. Henry Muirhead, of Cambuslang, Scotland, gives the following account of a fire-ball seen by his sister many years ago at the farm of Haggs, Glasford Parish, Lanarkshire, in *Symons' Meteorological Magazine* for May:—"During a fearful thunderstorm the farm hands were eagerly striving to cut and bring in a load of grass, but were obliged to give over in consequence of the lightning playing vividly on the scythes and forks. In the thick of the storm my sister saw a ball of fire, about the size of a boy's head, settle down on the ridge of a thatched outhouse. After remaining a few seconds, it fell gradually to pieces or powder, in a manner like to a shell of quicklime when slaked, the gleaming powder streaming down the thatch amid the pouring rain, but doing the roof no injury. If there was any noise from it, it was unheard."

ELECTRIC LIGHTING FOR MUSEUMS.—In the House of Commons, on Thursday week, Mr. Coope asked Mr. Shaw-Lefevre whether he was aware that the electric light had been used in the South Kensington and Jermyn-street Museums for upwards of two years without any accident occurring; whether he was aware that a code of regulations had been adopted jointly by the electric lighting companies and the fire insurance offices, reducing fire risks to a minimum; and whether he was prepared to take measures whereby the National Gallery and the British Museum might be lighted by electricity? To which Mr. Shaw-Lefevre replied that while admitting all that the hon. member had said to be true, he still remained of opinion that we have not had sufficient experience of the electric light to justify him in advising the trustees to use it in the National Gallery.

ELECTRIC LIGHTING AT BUCKINGHAM PALACE.—On the occasion of the State Ball at Buckingham Palace on Tuesday night, the ball room was most brilliantly lighted by means of 700 Swan incandescent lamps. The work of fitting up the lamps, wires &c., was carried out by the officials of the royal household under the superintendence of Mr. W. H. Massey, a well-known electrical engineer, assisted by Messrs. E. H. Liveing and A. H. Walker. The work was carried out in a very short space of time, and for a week before the night of the ball, those concerned were engaged night and day. The result was a grand success, and we believe that H.R.H. the Prince of Wales was very pleased with the lighting. The incandescent system is to replace gas on all state occasions for the remainder of the season. We shall hope to be able to give our readers some further details of this installation in a future issue.

A NOVEL IDEA.—Bazaar promoters, who are fond of novelty, cannot do better than follow the example which has been set them at St. Peter's Church, De Beauvoir-square, in the north of London. Here we are introduced to a fancy fair, which is being held in the crypt of the church; it was inaugurated on Wednesday, and is to last until Saturday (to-day). The crypt being dark even when the sun is at its full power, it was necessary to find some means of dispelling the darkness. Mr. Wharton, of the firm of Laing, White, and Wharton, of Holborn Viaduct, was called in, and has succeeded in lighting up this weird locality for a fancy fair, with something more than a "dim religious light." He has fitted up between 40 and 50 Swan lamps of 10 candle-power, the current being obtained from 54 cells, supplied by the Duplex Electric Light Company. The total current given is about 60 amperes. The lamps are in use from 3 o'clock until 10:30 or 11 p.m., and burn with great steadiness. The whole of the work has been carried out under the personal superintendence of Mr. Wharton.

ELECTRIC LIGHTING FOR GREENOCK.—At the last meeting of the Greenock Police Commissioners, a special sub-committee of the Law and Finance Committee submitted a report with reference to electric lighting, in which they proposed to make a written and personal representation to the Board of Trade, asking that the water-power of Greenock might be utilised, and that an extended period for experimental purposes should be conceded to the burgh. A report by Mr. S. Stewart. gasworks manager, giving an estimated cost of the proposed experiments within a limited area in the Sixth Ward, was also laid before the meeting. The area, it was stated, was bounded by Prospect Hill, Ann, Roxburgh, and Mount Pleasant-streets. The length of streets in the area was about 3,600 yards, and the power for lighting would b got from the Water Trust Premises at Prospect Hill. Mr. Stewart proposed to put up only eight arc lamps in the meantime, if the arc system were adopted, at a total cost of £1,000. He, however, recommended the incandescent lamp, and 90 to 100 such lamps fitted on the existing gas lamp-posts, together with every accessory, he estimated to cost £1,000.

ELECTRIC LIGHTING IN WESTMINSTER.—At a special meeting of the Westminster District Board of Works, presided over by Mr. Thomas Horn, on Wednesday, the parliamentary committee presented a correspondence with the Board of Trade with regard to the applications for provisional orders from electric lighting companies, and they recommended the Board to continue their opposition to the present introduction of electricity in their district, and to maintain such opposition throughout this session of Parliament. After a long debate it was resolved by a two to one majority, on the motion of Mr. Stewart Helder, seconded by Mr. J. K. Aston, "That the Board of Trade be informed that they (the District Board) did not think that the present requirements of the district justified them in negotiating with the promoters of provisional orders for the supply of electricity; and that they think no orders are necessary at the present time." The parliamentary committee were instructed to oppose the schemes mentioned in Major Marindin's report, and it was further resolved that the opinion of the parishioners should be tested by a public meeting on the subject.

ELECTRIC LIGHTING IN LONDON.—We understand that Major Marindin, the officer appointed by the Board of Trade, has made his report on the inquiry held at the Westminster Sessions House on May 10th, and that, as regards the St. Giles District, a provisional order has been granted to the Pilsen, Joel, and General Electric Light Co. (Limited), by arrangement with the local authorities. The area to be

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lighted by the Pilsen Joel Company will be the south side of New Oxford-street and High Holborn, from the centre line thereof, extending from Tottenham Court-road to Little Queen-street, and the houses, premises, and buildings abutting thereon, and an area bounded on the north by the centre line of High Holborn, from little Queen-street to the boundary of the parish of St. Giles-in-the-Fields, on the east by the said parish boundary line, and on the south by the houses on the north side of Lincoln's Inn-fields and the houses on the south side of Twyford's-buildings, and on the west by the houses on the west side of Little Queen-street. The Pilsen Joel Company have already established a lighting station in that area, and have been for some time past successfully lighting large business establishments from that station.

THE SHOCK FROM A WESTON MACHINE.—A short time since one of the line-men employed by the Citizens Electric Light Company, of Toledo, Ohio, which is running a central station supplying something over one hundred Weston arc-lights, received a shock from two twenty-light machines coupled together and supplying a forty-light circuit. He was making some change in the adjustment of one of the lamps, and took it out of circuit just before the time for starting up in the evening. Before he placed it in position again the current had been turned on without his knowledge, and he accidentally took hold of both terminals of the circuit and received the current from the two machines. The shock was so severe as to close his hands on the wires, and he fell from the step-ladder on which he was standing, his weight tearing him from the wires. His hands were somewhat burned, but he did not lose an hour's time from his work, and suffered no other injury or inconvenience. This shows the comparatively safe nature of the continuous current, as compared with the intermittent or undulatory current, which is used in some of the systems. A similar accident occurred in Boston a short time since, in which a line-man, under the same circumstances, suffered a shock from five ten-light machines coupled without receiving any injury.—*Electrical World*, New York.

THE CZAR'S CORONATION.—During the festivities that have been taking place at Moscow for the last week or so in honour of the Czar's coronation, that city has been illuminated from the top of her highest church spire to the lowest window ledge. Electric lamps have played a conspicuous part in the illuminations, and unlike the oil or tallow lamps that have also been used, have not been put out by the rain which has fallen at frequent intervals. Amongst the other buildings that were brilliantly lit up was the British Embassy. One hundred and twenty Swan lamps were arranged in decorative devices on the façade of the building, and produced an effect which is spoken of by the correspondents of daily papers as the greatest success of the illumination. The current was supplied from Bürgin machines, driven by a Robey engine, situate about 300 yards from the Embassy. The lamps were fitted on to a special form of holder, designed by Mr. A. P. Lundberg, which has been found to resist the action of the wind better than the original spiral form of spring holder, adopted by the Swan Company. Several trials were made with different coloured globes for the lamps, but, on the whole, Sir Edward Thornton considered that the effect of the white globes was the finest. This installation was carried out by Mr. N. W. Hornstedt, the British Vice-Consul, under the personal supervision of Mr. Norcliff Thompson, the London manager of Messrs. Crompton, Winfield and Co., the manufacturers of the machines.

LEGAL.—THE TELEPHONE SUIT.—The case of the United Telephone Company *v.* the London and Globe Telephone Company, mentioned in our note of last week, came on again before Mr. Justice Pearson on Friday week (25th May), when Mr. Hemming, Q.C., for the defendants, moved to dissolve the *ex parte* injunction granted on Tuesday week, and reported in our note, restraining the defendant company from interfering with the telephone wires, supports, and apparatus of the plaintiff company. The learned counsel stated that in fourteen out of the fifteen cases of interference mentioned to the Court on Tuesday the wires of the two companies had accidentally come into contact, and if the plaintiffs had communicated with the defendants' engineer the matter would have been remedied at once, nothing being needed but to tighten or slacken the wires. The fifteenth case, in which thirty-six wires running over Gresham-buildings had been bound together by a metal band, was entirely different, the defendant company having purchased the absolute right to set up poles and support and maintain wires over Gresham-buildings. The plaintiff company also claimed the right to carry their wires over Gresham-buildings, and disputed the defendant company's exercise of the right which they had purchased where it in any way interfered with them.—Mr. Justice Pearson said that he should direct the engineers of both parties to co-operate for the purpose of freeing the plaintiffs' wires from obstruction in the fourteen instances, and he should continue the injunction as to the fifteenth instance brought forward until Thursday (May 31).

ELECTRIC LIGHTING FOR EDINBURGH.—On Monday last Major Marindin, on behalf of the Board of Trade, opened an inquiry at Edinburgh regarding an application by the Brush Electric Light Company of Scotland for a provisional order to supply electricity for lighting purposes, &c., within a certain area in that city. The representatives of the local gas companies were in attendance, though the Electric Light Company appears to have left their advocate to fight their battle by himself, as he stated in his opening speech that "he had not the benefit of the attendance of any of the responsible members of the company." For the promoters Mr. Paton, station master at the Waverley Station, Edinburgh, gave evidence as to the use of the Brush light there for some time past, and thought that "it would be a misfortune to revert to any other form of artificial light." Mr. J. B. Howard, who has been connected with Edinburgh theatres for some sixteen or seventeen years, stated that he was having a theatre erected in Grindlay-street in which he intended to use the electric light permanently, having apparently been influenced so to do by the example of the Savoy Theatre, London. He was going to use Swan lamps and Higgs dynamos. Several commercial men were then examined, and gave evidence to the effect that they would be glad to have the electric light introduced into their houses, shops, and works. Having brought forward his evidence, Mr. Graham Murray, for the promoters, then formally moved for an adjournment. This, Major Marindin, said was quite out of the question; in fact, the standing order of the House of Lords would prevent any adjournment being granted. It would be of no practical use whatever, but simply a waste of time. Under those circumstances, considering the absence of any information as to the position of this company, their capital, and their means of carrying out this order, it would be quite unnecessary for those who appeared for the objectors to speak. He would report against the preamble of the Bill. The objectors were awarded costs.

ELECTRIC LIGHTING IN JAPAN.—We take the following from the *Japan Gazette* for April 6 :—"The official trial of the electric lights just erected at the Yokosuka naval

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arsenal was held last night (Thursday, April 5) by the Admiralty authorities. The apparatus consists of the large No. 8 Brush dynamo electric machine, driving forty lights of 2,000 candle-power each, on a circuit of No. 8 copper wire B.W.G., three miles in extent. The electric lamps are erected in the various machine, carpenter, boat and spar shops, in the two docks, and in the shipbuilding yards. The driving power is derived from two engines used also to pump the water out of the docks, the adjustments being economically arranged so that when the dock lights alone are burning a single engine will do the work. All the workshops are illuminated as by a flood of daylight, and the light in the docks is so brilliant and equally distributed that night work can hereafter be carried on with the same facility as day work. The lights in the docks are arranged with counterweights to lower to any depth, thus throwing the mass of illumination under a ship's bilges, on her bottom, or alongside, as may be required. These arrangements will be of great importance to the arsenal, as the docks have heretofore been so overcrowded with work that ships have been obliged to make application to enter long in advance or suffer the inconvenience of prolonged delay. Night work will now be done, and in fact, if there is sufficient work, of which there is little doubt, double gangs of labourers may be employed, and the uses of the dock will be practically doubled. The electric lights in the shipbuilding yards are placed on standards 25 to 30ft. high, and are fitted with adjustable reflectors to throw the light wherever needed. There are five lights in these yards where several large ships are now on stocks. The Japanese authorities were greatly delighted at the completeness and success of the illumination. The Swan incandescent light was exhibited at the trial, the engine house being thus illuminated. These lamps will be ultimately run from the new Brush accumulator. This important work, the first of its kind in Japan, has been carried out under the direction of Mr. J. Potter, of the Brush Electric Company, the details being executed by Mr. C. W. Phipps, the company's electrical engineer. Mr. Potter also introduced the electric light into Shanghai."

A Telephone Suit in Dundee.—The case of Messrs. Stewart, manufacturers, of Dundee, *v* the National Telephone Company, of the same town, has recently been settled, after considerable delay. The plaintiffs' case was that for the payment of £15 per annum to the company they became entitled to the use of three sets of telephone wires and apparatus at or from Kinnaird Works, Dundee, and Reform-street, Dundee, for five years from October, 1882, and that they were also entitled to communicate by means of the defendants' telephonic service to Forfar, Broughty Ferry, and such other neighbouring towns as might be connected with the defendants' telephonic exchange in Dundee. The company's defence was that they had only agreed to give the local connection. When the case was heard in the Dundee Sheriff Court in November, 1882, judgment was given for the defendants, but on appeal to the Court of Session the case was remitted back to the sheriff to, in the words of the Scotch courts, "allow full proof of the pursuers' averments." Accordingly the case was fully gone into in Dundee, and evidence taken in London by commission and forwarded to Dundee. The result of this fresh trial has been that Sheriff Cheyne has found for the plaintiffs. The latter relied for their case upon the wording of the agreement between themselves and the telephone company. According to this document the defendants agreed to give the plaintiffs telephonic communication between their works and office in Dundee, and "all persons, firms, or stations, whether in Dundee or neighbouring towns, that might during the existence of the agreement be connected or in communication with the defendants' telephonic exchange in Dundee." We quote from Sheriff Cheyne's judgment. It appeared in evidence that the trunk wire between the Dundee and Forfar Exchange was held by the defendants on a lease from the Postmaster-General for one year from the 12th September, 1882. That the conditions of this lease were that they should only allow such subscribers to use the trunk wire as had signed a special agreement with the Postmaster-General, and that the number of subscribers who might use it should be limited to eight. It also appeared that at the date of the action this number had not been reached, and that the plaintiffs were quite willing to enter into the special agreement with the Postmaster-General, but that, until after the action had been brought, they were not aware that it was necessary to enter into any such agreement, nor had they been asked to do so.

Death of Mr. W. E. Sawyer.—The death of this well-known electrician is announced as having taken place in New York on the 15th May. Many of our readers are doubtless familiar with his work on "Electric Lighting by Incandescence, and its Application to Interior Illumination," published early in 1881, by Van Nostrand, in New York, and Spon, in London, which we noticed at some length in our issue of June 11, 1881. Mr. Sawyer was a prolific inventor and had taken out patents for incandescent and arc lamps, as well as dynamo machines, and it is said that just before his death he was turning his attention to electric railways, with the object of patenting an improved system of his own. He was an eminently practical inventor. We find him first brought into prominence through the purchase of his inventions by the first electric lighting company started in America, viz., the United States Electric Light Company, who, it is said, gave him 50,000 dollars for them, and appointed him on their staff at a high salary. His connection with this company was, however, of short duration. We next hear of him as engaged in experiments on a system of incandescent lighting in conjunction with Mr. Mann, the result being the formation of the Sawyer-Mann Electric Light Company, to work the system. This company failed, and was followed by others, all formed to work Mr. Sawyer's patents, which suffered the same fate. He appears to have been one of those anomalies often to be met with in this world, viz.: possessed of great talents, but weak character, extremely clever, but unbusinesslike and unstable. Accordingly we find him often in difficulties, the most serious of which was hanging over his head at the time of his death. It appears that in May, 1880, Mr. Sawyer was boarding in the same house with a Dr. Steele, that a quarrel arose between them, which ended by Mr. Sawyer shooting Dr. Steele. This was on the 5th May. Mr. Sawyer was arrested, and when his trial came on, which did not happen until March, 1881, he was convicted and sentenced to four years' imprisonment with hard labour. Against this sentence an appeal was made, and as Mr. Sawyer was in bad health he was permitted to remain at home pending the appeal. The Court of Appeals affirmed the decision of the Court of General Sessions, and he then sought pardon from the governor. As his health was such that his removal was considered dangerous, he was permitted to remain at his house. The District Attorney consented to delay in moving for sentence for one month, which expired on the 16th May, but before the time had expired he received official notice of the death of Mr. Sawyer. Truly, a pitiful ending to a life which promised so much.

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JOHN PENDER, Esq., M.P.

The gentleman whose portrait we give in this number has been and is one of the most prominent figures in the history of submarine telegraphy. Indeed, it may safely be said that but for his indomitable perseverance submarine telegraphy would even now be in its embryo stage. It needs something more than the ordinary qualities of a keen man of business to grasp the possibilities of a new scientific application at its very birth. It needs, too, something over and above the ordinary business spirit to risk the embarkation of a considerable capital, to risk the loss of prestige that would necessarily follow if inducements held forth should lead friends also to largely subscribe capital and then the enterprise should fail; but this is a comparatively small part of the risk which Mr. Pender took upon his shoulders in those early historical days of submarine telegraphy. He, in conjunction with friends, not only embarked and influenced capital, but suggested a policy, foresaw the rocks and shoals upon which the enterprise might be foundered, and so shaped his policy as, if not to avoid them altogether, to make them practically harmless. It will be said that no one man could in these degenerate days emulate Achilles. Perhaps not; yet we have giants in finance, and one, not the least important characteristic of such men, is choice of colleagues. Those who know the co-workers with Mr. Pender will know we do not exaggerate when we say that among them are some of the keenest business men—men with broad principles and far-seeing instincts, not second to any in this or any other country. Alexander must have known the merits of his men when he sighed that there were no more worlds to conquer.

JOHN PENDER, Esq., M.P.

We shall very briefly sketch the career of Mr. Pender. He was born in the Vale of Leven, Dumbartonshire, in 1816, and received his earlier education in the parish school, but later on at the high school of Glasgow. At an early age he entered the counting house of a factory in the Vale, and being accurate and quick with figures, doing well and thoroughly whatever he undertook to do, we find him at the age of twenty-one exalted to the position of manager of the factory. The mere management of a factory, however, did not give sufficient scope to the energies of Mr. Pender, and he established himself as a merchant in Glasgow, buying and selling in home and foreign trade the goods of which he had obtained a thorough knowledge in the factory. A few years after the house extended itself to Manchester, and became one of the leading distributors of Scottish and Lancashire looms. The trade was world-wide, and success followed, not only in the shape of increasing business but in the accumulation of a large fortune.

Mr. Pender joined the Board of the British Telegraph Company at its formation, and retained his seat after the amalgamation with the Magnetic Telegraph Company, till the purchase of inland telegraphs in 1870 by the Government. In 1855 he was an ardent and active supporter of Mr. Cyrus W. Field in the advocacy of an Atlantic cable. The shares in this first Atlantic Company each cost £1,000, and Mr. Pender and his personal friends were among the earliest contributors. The failure of the first attempt only served to increase the persistent advocacy of Mr. Pender in the enterprise, and in 1864 he suggested the formation of the Telegraph Construction and Maintenance Company, to amalgamate the works of Messrs. Glass, Elliot, and Co., and the works of the Gutta Percha Company, and became chairman of the company. In 1865 an attempt was again made to lay the cable, and again failed, but failed in such a manner as to make success almost certain. Mr. Pender (as chairman) suggested that each member of his Board should subscribe £10,000 as an evidence of confidence in the ultimate success of the work, and so £100,000 was immediately obtained. Financial arrangements were made for the balance, the 1866 cable was made and successfully laid, and the 1865 cable picked up in 2,000 fathoms, and put into good working order. Here was a grand success, and proved the wisdom of those who had undertaken the financial part of the business as conclusively as it proved the ability of sailors and scientific men to carry out the work. Mr. Pender's work in connection with submarine telegraphy had but commenced. He saw the necessity for greater facilities for communicating with our Indian Empire and our great Eastern colonies, and in 1869 retired from the position of chairman of the Telegraph Construction Company to devote his whole energies to the laying a cable to India. The British Indian Cable Company was formed, Mr. Pender becoming chairman, and guaranteeing himself £50,000, besides influencing friends to subscribe another £50,000. The cable was successfully laid, but Mr. Pender's aim was to complete a system of cables connecting England with her Eastern dependencies, to be under the sole control of England. Gradually connections were made and duplicated, and finally the various companies controlling these cables amalgamated into one company, the "Eastern Telegraph Company." The extension of the cable system from India eastward was carried on originally by three companies, which ultimately amalgamated to form the "Eastern Extension Company," with Mr. Pender as chairman, since which the work has been going on almost without cessation. More recently still the "Cape Cable" was projected and carried out, principally under the auspices of the Eastern Telegraph Company. To sum up these facts briefly, it may be said that Mr. Pender has advocated and carried out a policy which has united the various systems under English control, whilst retaining an international character for submarine telegraphy. The results have been that Great Britain is now connected with all the important islands in the Mediterranean and the Levant, with our North American colonies, with the vast land line system of the United States, with our Indian

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Empire and its network of telegraphs, with the Straits Settlements, Cochin China, China, Japan, Java, Australia, and New Zealand.

In politics Mr. Pender is a staunch Liberal, though not one who likes hasty or extreme views. He sat in the House of Commons for Totnes in 1865-6, but his connection with that borough was short-lived. In 1868 he contested the county of Linlithgow, against Mr. M'Lagan, who gained and still holds the seat. In 1872, it an interim election on the retirement of Mr. Loch, Q.C., he offered himself as a candidate for the northern (or Wick) burghs, and had to fight two contests before the election was decided in his favour by a large majority, and since this time we believe he has represented that constituency.

SOME ELECTROSTATIC AND MAGNETIC RELATIONS.

BY OLIVER HEAVISIDE.

(CONTINUED FROM PAGE 583, VOL. X.)

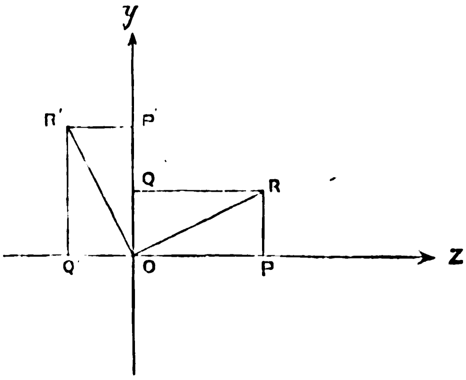
First let X vary in amount only in its own direction, then, in passing from any point through the distance dx parallel to x, X becomes $X + \frac{dX}{dx}dx$, where $\frac{dX}{dx}$ is the rate of increase. Let there be a cubical element of volume $dV = dx\,dy\,dz$, whose edges are parallel to x, y, z, and consider the amount of X entering and leaving the space. Two opposite faces are perpendicular to X, and the four others are parallel thereto. The latter may be disregarded, whilst the amount of X entering one of the first pair is $X\,dy\,dz$, and leaving the other $\left(X + \frac{dX}{dx}dx\right)dy\,dz$, both faces being of area $dy\,dz$. The excess of the latter over the former amount is $\frac{dX}{dx}dV$, that is, $\frac{dX}{dx}$ per unit volume. This is the divergence of the vector in the special case taken, since Y and Z are zero.

Next consider the variation of X perpendicular to x, *i.e.*, in the plane y, z, or parallel thereto. If we start from any point and go in different directions in this plane, X may or may not vary, but if it should do so, there will be in general a certain direction in which it increases fastest, and another direction, crossing the first at right angles, in which there is no variation, just as when one is upon the side of a hill there is a direction of greatest slope at any point, and a level direction perpendicular to the first, disregarding singular points requiring special treatment. $\frac{dX}{dy}$ and $\frac{dX}{dz}$ being the rates of increase of X along y and z, the resultant of vectors of these lengths drawn along y and z is a vector in the direction of most rapid increase of X in the plane y, z, of length equal to the rate of increase. Now, rotate this vector through a right angle in the plane y, z, *i.e.*, about the axis of x, so that in its final position it points along the axis of no variation, it will then represent the curl of X. It will come to the same thing if we rotate the original vectors through a right angle, and compound them afterwards; and by this we see that the components of the curl of X are $+\frac{dX}{dz}$ along y, and $-\frac{dX}{dy}$ along z, when the rotation is left-handed about the axis of x. Let the plane of the paper be the plane of y, z, and the positive direction of the axis of x be downward through the paper at the point O where the variation of X is estimated. Let OP and OQ be of lengths $\frac{dX}{dz}$ and $\frac{dX}{dy}$ respectively. Their resultant is OR, showing the direction and rate of most rapid increase. Rotate the rectangle OPRQO about the axis of x through a right angle into the position OP'R'Q'O, then OR' will represent the curl of X, and OP' and $-$ OQ' its components along y and z.

Now let the vector whose space variation is required be Y everywhere parallel to y, and treat it similarly. We shall find its divergence $= \frac{dY}{dy}$ from the variation in its own direction, and its curl to have components $+\frac{dY}{dx}$ along z and $-\frac{dY}{dz}$ along x, by rotating the resultant space variation in the plane z, x, through a right angle about the axis of y.

And with a vector function Z everywhere parallel to z treated similarly, we shall find its divergence $= \frac{dZ}{dz}$, and the components of its curl to be $+\frac{dZ}{dy}$ along x and $-\frac{dZ}{dx}$ along y.

Finally, if we compound X, Y, and Z, we obtain a vector R, which is arbitrary, and, consequently, may vary both in direction and magnitude from point to point. Its divergence will be the sum of the separate former divergences, or $\frac{dX}{dx} + \frac{dY}{dy} + \frac{dZ}{dz}$, which expresses the whole amount of R leaving the unit volume, reckoned algebraically. And its curl will be represented by the resultant of the three vectors representing the curls of X, Y, and Z (the first being



OR' in the figure, and the second and third two other vectors in planes perpendicular to the plane of the paper and to each other), and its components will be the sum of the former components, and are consequently $\frac{dZ}{dy} - \frac{dY}{dz}$ along x, $\frac{dX}{dz} - \frac{dZ}{dx}$ along y, and $\frac{dY}{dx} - \frac{dX}{dy}$ along z.

17. We thus find the vector curl of R by compounding three vectors which represent respectively the rates of greatest increase in three rectangular planes of the components of R perpendicular to the planes, each of the three vectors being then turned through a right angle in its proper plane. Now this selection and subsequent rotation is effected mechanically when we use the operator ∇ according to quaternion rules. For, if we denote by i, j, k three rectangular vectors of *unit* lengths parallel to x, y, and z, then Xi will denote a vector of length X parallel to x, and similarly for Yj and Zk, consequently we may write $R = Xi + Yj + Zk$ with the convention that the sign of addition signifies compounding as velocities. Now the full expression for ∇ is $i\frac{d}{dx} + j\frac{d}{dy} + k\frac{d}{dz}$, hence

$$\nabla R = \left(i\frac{d}{dx} + j\frac{d}{dy} + k\frac{d}{dz}\right)\left(Xi + Yj + Zk\right).$$

Expand this expression, with the further conventions $i^2 = j^2 = k^2 = -1$, and $ij = k, jk = i, ki = j$, and we obtain,

$$\nabla R = -\left(\frac{dX}{dx} + \frac{dY}{dy} + \frac{dZ}{dz}\right) + i\left(\frac{dZ}{dy} - \frac{dY}{dz}\right) + j\left(\frac{dX}{dz} - \frac{dZ}{dx}\right) + k\left(\frac{dY}{dx} - \frac{dX}{dy}\right),$$

i.e., ∇R = convergence R + curl R.

The meaning of the rules $ij = k$, &c., may be interpreted

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thus: j signifying a unit vector parallel to y, and k another parallel to z, let i be taken to mean, not a unit vector parallel to x, but a rotation through an angle of 90° about x as an axis. Then since j rotated 90° about the x-axis is turned into coincidence with k, we have $ij = k$. Similarly for the other products. As for the squares, we may verify $i^2 = -1$ thus:—Rotate j a second time through 90° about the axis of x. The first rotation brought j into coincidence with k, the second brings it into the same line as at first, but pointing the other way. Thus $i^2j = -j$, or $i^2 = -1$. This use of vectors to denote either lines drawn in definite directions, or else rotations about such lines, is the foundation of the great simplicity and conciseness of quaternion operations and expressions; it is justified by the already mentioned identity of the rules for compounding velocities and rotations, and by its always leading to results which are found to be correct when expanded; but it must be confessed that this double use of the same symbols makes it difficult to establish the elementary parts of quarternions in an intelligible manner. However, this is merely parenthetical, and we shall have no more concern with quaternion expressions beyond noticing that the properties of the quantities defined in section 8 (p. 559 ante), relating to an arbitrary system of magnetic force B, divided into two systems B_1 due to current C_1, and B_2 due to magnetism C_2, may be thus formally expressed. Since ∇ operating on a scalar function gives the vector rate of greatest increase, and on a vector gives its convergence and its curl, or its curl only if it has no convergence, and conversely, we have simply

$$\nabla Z_1 = A_1, \quad \nabla A_1 = B_1, \quad \nabla B_1 = C_1, \quad \nabla C_1 = D_1;$$
$$-\nabla Z_2 = A_2, -\nabla A_2 = B_2, -\nabla B_2 = C_2, -\nabla C_2 = D_2.$$

In the first line, the ∇ signifies "curl" only, because the quantities are vectors of no divergence. In the second line (relating to the magnetism) it is convergence when operating on a vector, and the vector rate of increase when operating on a scalar. The presence of the $-$ sign all along the second line makes it awkward to combine the quantities consistently as they stand. But by simply changing the sign of C_2 and A_2, so that C_2 when positive represents S. magnetism instead of N. we get things straight. Z_2, B_2, and D_2 are unchanged, and denoting $-C_2$ by C'_2 and $-A_2$ by A'_2 we have

$$\nabla Z_2 = A'_2, \quad \nabla A'_2 = B_2, \quad \nabla B_2 = C'_2, \quad \nabla C'_2 = D_2.$$

We may now combine the quantities with suffixes $_1$ and $_2$; thus $B = B_1 + B_2$, &c., and we have

$$\nabla Z = A, \quad \nabla A = B, \quad \nabla B = C, \quad \nabla C = D,$$

where Z, B, and D are pure vectors, Z being the v.-potential of B, which is the actual resultant magnetic force due to currents and magnetism, and B the v.-potential of D. On the other hand, A and C are both scalar and vector, *i.e.*, quaternions, though still A = potential C.

The operator ∇ contains the whole theory of potentials, whether of scalars or vectors. But owing to the remarkably different nature of the effects of ∇ on different functions, it conduces to clearness to distinctly separate the space variation of a scalar, which is easily grasped, from that of a vector, and to instead speak of the curl or the divergence of the latter, as the case may be, and as we have always done hitherto.

(TO BE CONTINUED.)

An Electric Railway for Paris.—A French paper says that the Municipal Council of Paris are considering a project for the construction of an electric railway on the outer boulevards, from La Vilette to the Place Moncey. It is to be 3,077 metres long (about 3,364 yards), and will have nine stations. The permanent way will be erected at a height of 4·75 metres (14ft.) from the road, and the journey will be accomplished in twenty minutes.

ELEMENTARY ELECTRICITY.—XI.

If the hind legs of a frog, together with the portion of the spine from which the lumbar nerves arise, be separated from the body and the legs denuded of their skin, and if a piece of zinc be placed in contact with the nerves while the feet are laid upon a silver plate, no effect will be produced so long as there is no contact between the metals; but if the zinc and silver be made to touch each other, or be joined by a wire of any metal, the legs will immediately contract. According to Matteucci this experiment, in a slightly different form, was shown by Swammerdam to the Grand Duke of Tuscany in 1678. The action was rediscovered in 1786 by Galvani, who considered that it was due to an electric action between the nerves and the muscles. Volta held that the action was due simply to the contact of the dissimilar metals. In 1803 Aldini, a nephew of Galvani, visited London, and showed several experiments in confirmation of his uncle's theory, *i.e.*, that the action was physiological. His experiments showed that muscular contractions could be produced by the action of the nerves upon the muscles without the aid of metals, and subsequently Valli and Matteucci showed that electric currents were produced between nerves and muscles without the intervention of metals. The powerful currents produced by the torpedo, the gymnotus, and other animals confirmed the possibility of producing a current by purely physiological action. An account of modern investigations in this subject would carry us far beyond the limits of these articles. We may, however, mention that by means of a delicate galvanometer, containing 20,000 turns of wire, Du Bois Reymond showed that, if a muscle be cut across, the sides of the fibres are at a higher potential than their cut extremities. One of the greatest hindrances to experiments of this class lies in the great difficulty of obtaining a connection between the animal substance and the terminals of the galvanometer, which may not introduce an electromotive force on account of polarisation, a phenomenon which we shall refer to later on.

Although Galvani rightly maintained the existence of electric currents arising from physiological causes, he nevertheless admitted that in the particular case of the contraction of the frog's legs above referred to the contact of the metals was essential. Many experiments have since shown that electric currents, from whatever cause arising, are capable of producing muscular contractions. If one terminal of a telephone be connected with the sciatic nerve of a recently-killed frog and the other with the gastrocnemius muscle, the frog will leap from his place on calling "froggy" through the telephone.

By means of his condensing electroscope Volta endeavoured to show that electrification is produced by the simple contact of dissimilar metals. By causing a piece of zinc to touch one plate of the condenser and a piece of copper to touch the other, the zinc and copper being made to touch each other, one of the plates became electrified positively and the other negatively. On removing the condensing plate the gold leaves diverged with the charge accumulated in the receiving plate. We shall return to the consideration of the electrification produced by the contact of dissimilar metals shortly.

In 1800 Volta constructed the voltaic pile. It consisted of a series of discs of copper, zinc, and flannel, which were placed one above the other so as to form a pile. The flannel discs were moistened with dilute acid or solution of common salt. Starting with a zinc disc at the bottom, the order in which the plates were arranged was—zinc, flannel, copper, zinc, flannel, &c., the same order being maintained throughout, and the pile terminating with a copper plate. To prevent the liquid running between the copper and zinc plates they were soldered together where they were in contact. On connecting the zinc and copper terminals of the pile a current flowed from the copper to the zinc terminal through the pile.

The "crown of cups" of Volta and the early batteries of Wollaston and others consisted of plates of two dissimilar metals (generally copper and zinc) placed in vessels or cells, containing dilute acid or solution of salt, and connected alter-

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nately so that the copper of one cell was connected with the zinc of the next, and so on. On connecting the final copper and zinc plates by a wire a current flowed round the circuit as in the voltaic pile. In Wollaston's battery the copper and zinc plates were immersed in cells containing dilute sulphuric acid.

In 1830 Sturgeon introduced the improvement of amalgamating the zinc plates, thus preventing "local action" and preserving the zinc from the action of the acid, except when the current is flowing in the circuit. This improvement obviated the necessity of lifting the plates out of the acid when the battery is not in use.

The followers of Volta maintained that the electric current in the voltaic cell was due entirely to differences of potential produced at the three places of contact of the metals with the acid, and with each other. They held that although in the case of three metals in contact at the same temperature the difference of potential between the metals at the three points of contact balance one another, so that there is no resultant electromotive force round the circuit, yet this is not the case when one of the metals is replaced by a liquid which can act chemically upon one or both of the remaining metals. Thus, supposing the potentials of zinc and of copper to be both lower than than that of sulphuric acid when the metals are in contact with the acid, and in electrical equilibrium, and the potential of zinc to be higher than that of copper when the metals are in equilibrium, the supporters of the voltaic or contact theory maintained that the difference of potential between the sulphuric acid and the zinc necessary for equilibrium was greater than the sum of the differences of potential between the acid and the copper, and between the copper and the zinc, the difference being the resultant electromotive force which urges electricity from the zinc through the acid to the copper and back to the zinc through the metallic junction, when the three substances are connected as in the voltaic cell.

Faraday seems to have seen the necessity for the energy of the electric current being derived from the chemical action going on in the cell, and he consequently regarded this chemical action as the primary source of the electromotive force, as it certainly is of the energy of the current. Faraday supposed the chemical attraction to throw the electrolyte (acid) into a state of electric "polarisation," which state he supposed to be relieved by electric discharge (current) when chemical action actually takes place.

The supporters of the voltaic or contact theory have spent much time in endeavouring to determine at which of the three places of contact in the voltaic cell the chief difference of potential occurs, and many experimentalists have maintained that the electromotive force is due principally or entirely to a difference of potential at the contact of the *dissimilar metals*, and have supposed that the differences of potential at the contacts of the metals and electrolyte are either zero or comparatively small. Several experiments have been cited in support of this view. One of the most recent is due to Sir William Thomson, who showed that when two equal semicircles, one of copper and the other of zinc, are placed with their diameters in contact and a positively electrified "needle" suspended above them, so that, before the plates are made to touch, the needle points in the direction of the common diameter, on making contact between the copper and the zinc the needle turns towards the copper. If a quadrant electrometer be constructed with two quadrants of zinc and the other two (alternate quadrants) of copper, the needle, if positively electrified, will turn so as to enter the copper quadrants, the difference of potential indicated being nearly equal to the electromotive force of a cell consisting of copper and zinc immersed in dilute sulphuric acid. It was at first supposed that these experiments proved a difference of potential to exist between the copper and the zinc sufficient to account for the electromotive force of the voltaic cell. It will be seen, however, that the electrified needle does not move *within the substance* of the copper and zinc, but in the air around the metals, and the experiment therefore only serves to determine the difference of potential of the air near the copper plate, and of that near the zinc plate.

In 1878 Mr. John Brown, of Belfast, experimenting with copper and iron, showed that while the positively electrified needle turned towards the copper quadrants in an atmosphere of air the action was reversed in an atmosphere of sulphuretted hydrogen, the needle turning towards the iron, thus indicating that the gas in the neighbourhood of the iron had a lower potential than that in the neighbourhood of the copper. Hence the motion of the needle is not due to a difference of potential between the metals themselves caused by their contact.

By experiments on the contact electrification of different metals, Volta arranged several of the metals in a series, such that each metal in the series was positive to those below and negative to those above when contact was made between them, while the amount of electrification was greater the farther the metals were separated from each other in the series. It is clear from the experiment of Mr. John Brown, just referred to, that the series can hold good only when the metals are surrounded by certain liquids or gases. Volta's series was determined from experiments in air. Experiments in sulphuretted hydrogen would have led to very different results. The series was the following:—

Zinc,
Lead,
Tin,
Iron,
Copper,
Silver,
Gold.

Platinum and carbon hold a position below gold in the series.

The only reliable method at our command for determining the difference of potentials between two metals in contact is based upon the Peltier effect. When electricity flows from a metal at a high potential to one at a lower potential work is done by the electric forces, and as there is no other source of energy (in a thermo-electric circuit) this work must be derived from heat absorbed at the junction, the absorption constituting the Peltier effect.* Thus, if Q units of electricity pass from one metal to another, the difference of potential being E, a quantity of heat mechanically equivalent to Q E ergs must be absorbed. By measuring the heat absorbed and the quantity of electricity that passes, we can determine E the difference of potential between the two metals. Similarly, if the current passes from a metal at low potential to one at a higher potential, work will be done against the electric forces, and a corresponding amount of heat will be generated. Thus the heat absorbed or developed at a junction of two metals, and constituting the Peltier effect, serves to measure the difference of potential of the two metals. Applying this test to copper and zinc at ordinary temperatures, it appears that the difference of potential is less than the millionth part of the electromotive force developed by a pair of copper and zinc plates immersed in dilute sulphuric acid, and, moreover, the copper is at a higher potential than the zinc. Hence it appears that the difference of potential due to the contact of zinc and copper may safely be neglected in discussing the theory of the voltaic cell.

If we apply the same test in order to determine the difference of potential between either of the metals and the acid in contact with it, we at once meet with a new difficulty, for we can no longer say that when work is done by the electric forces, the only source of energy is the heat absorbed, or that when work is done against the electric forces the whole of the energy expended must appear as heat, inasmuch as a chemical action is going on in contact with the metallic surfaces. If we knew how much heat was being developed or absorbed by this chemical action we might apply the necessary corrections, but though we know what is the whole amount of heat developed (or absorbed) in the battery cell (or the decomposing cell) we do not know what is the exact nature of the action which takes place in the neighbourhood of each metal plate. For example, in the case of a copper and a zinc plate immersed in dilute sulphuric acid we know how much heat is developed when a pound of zinc is dissolved, and the corres-

* The Peltier effect will be discussed when we come to speak of thermo-electricity.

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ponding amount (about half an ounce) of hydrogen liberated; but when the battery is in action the hydrogen is not liberated at the zinc plate, but in contact with the copper plate, and we do not know what is the condition of the hydrogen while it is travelling from the zinc through the acid to the copper plate. Thus, it may happen that the hydrogen, before it can be liberated as free gas at the surface of the copper plate, must absorb a considerable amount of heat, and this effect would mask the heat developed or absorbed by the electricity in entering the copper plate from the acid; while in the neighbourhood of the zinc plate the heat developed by the chemical action would be in excess of that due to the solution of the zinc and the liberation of *free* hydrogen, by the unknown amount of heat absorbed by the hydrogen when liberated from the copper plate.

(TO BE CONTINUED.)

CORRESPONDENCE.

GAS ENGINES AND THE FUTURE.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In your issue of the 19th May Mr. R. E. Crompton asks, "What can the makers of gas engines do for us" (electricians)? and further desires to know whether, with gas at 2s., an engine of 500 horse-power can be worked for 4d. an hour per horse-power, including oil and attendance. Is 4d. a misprint for $\frac{1}{4}$d.? Otherwise I am at a loss to understand the figure at all.

With gas at 1s., one farthing would be a rough approximate estimate of the cost per hour per indicated horse-power of gas, water, oil, and attendance, of an engine of our make indicating 500 horse-power, and giving off about five-sixths of this on the brake.

But why should Mr. Crompton pay so much as even 1s. per 1,000 feet for gas? Let him make gas from anthracite coal, as we are now successfully doing on Dowson's principle, and he shall have an indicated horse-power for, say, $\frac{1}{15}$th of a penny per hour, with anthracite at 10s. per ton—or, say, $1\frac{1}{2}$lb. of anthracite per indicated horse-power per hour.

No one has as yet built a gas engine to indicate so much as 500 horse-power, and to do so an engine with a good many cylinders will, in my judgment, be necessary. Excepting this multiplication of cylinders, I see no difficulty in complying with all Mr. Crompton's requirements, or at least all that seem essential to me. The first cost of a gas plant and gas engine to indicate 500 horse-power need not, if many were required, exceed the first cost of a steam engine and boiler of the class, say, that consumes 30 per cent. more coal than the aforesaid gas engine. The cost of attendance and oil for the gas engine and gas plant would not exceed that required for the steam engine and boilers, and the cost of water being infinitesimal in the case of the gas engines, would form another very great advantage—condensing engines being required to obtain a horse-power for 2lbs. of coal per hour. The space occupied by the steam and gas plants respectively would be about the same.

Against this list of advantages offered by the gas engine plant must be set the fact that it would be comparatively more experimental, and that consequently most people would prefer to pay more money and avoid this risk. But if Mr. Crompton is willing to run this risk, I shall be glad to discuss it with him further in private.—Yours &c.,

Manchester, May 28, 1883. F. W. CROSSLEY.

P.S.—Since writing the above I am informed that Mr. Crompton has corrected the 4d. into $\frac{1}{10}$d. Considering what we say in our prospectus about the Otto engine, this is mysterious in another way, as he is now asking for *almost* what we are commonly affirming. But as my letter has reference mainly to the cheaper gas, I may leave the illuminating gas part of it as it stands, and without further comment. The number of cylinders required to develop the power asked for by Mr. Crompton, while adding to the complexity of the engine, will, I may, perhaps, be allowed to add, give the great steadiness of turning which he also desires.

"INFORMATION WANTED."—MEDICAL MAGNETISM.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: The editorial appended to the letter addressed to me might answer "Neuralgia," p. 33. However, if he wishes to make a magneticon, let him take two pieces of calico to form a belt to surround the part and fit them with buckles or other fastenings; they should be sewn across in ribs as stays are, in which strips of steel can be inserted. Let the strips of thin steel, say watch spring, be smoothed at the ends, and well magnetised by a magnet. The querist can then insert them in the places prepared for them, after sewing them up in wash leather. If my advice is taken, they would be put together in pairs with N and S poles in contact. They would then retain their magnetism a long while and exert no external action whatever, or slips of thin whalebone may be substituted with advantage. The essential point is to line the belt with a slip of good rough flannel, which can be removed at intervals and replaced with new, not washed and put back.

I used to think the magnetic appliances mere inert affairs, having possibly a use in stimulating the imagination (I know a person who says he keeps off rheumatism by always carrying a fresh raw potato in his pocket), but some of the medical gentlemen have brought forward evidence to prove that the magnets do really act upon the body, and the result is to convince me they may possibly do mischief. They cannot really do anything except disturb the circulation of the blood; they cannot assist it because they cannot possibly put any energy into the body. But, as the blood is magnetic, it is quite possible for an external magnet to arrest its motion and cause a congestion at the polar points; and in what way this, the only conceivable real action, can be beneficial I cannot imagine.

But anything whatever in which a person believes will unquestionably do good. By stimulating hopeful expectation it will assist the action of the liver (just as, conversely, a gloomy, apprehensive state of mind will derange its action), and thus benefit will result; for rheumatism and neuralgia are undoubtedly traceable to imperfect action of the liver, and consequent accumulation of waste products which ought to have been removed. But whatever my ideas as to the medical "uses of the imagination" I cannot possibly, as a man of science, actually support a physical explanation which is obviously incorrect. Such is the case with the assumed effects of magnets, which have always been the favourite mine for perpetual-motion mongers and quacks of all sorts; simply because magnets seem, to those who do not understand the truth, to possess an inexhaustible power of doing work, whereas, as a matter of simple fact, they can do no work at all unless an external supply of energy is provided.—Yours, &c., J. T. SPRAGUE.

EARTHQUAKES AND THEIR ORIGIN.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I have read with great interest your Zante correspondent's letter, published in *The Electrician* of April 28, and am happy to be able to confirm from personal observations much of what he states in it.

Crete, like nearly all the islands in the Eastern Mediterranean, is subject from time to time to earthquake shocks, more or less violent, and although since the catastrophe of 1856 (when nearly every village on the island was destroyed and the town of Candia reduced to ruins) there have been no really serious shocks, we are still frequently reminded of what may possibly yet be in store for us, despite the generally believed theory that the volcano which opened during the earthquake of 1856 in the Bay of Santorin (an island about 50 miles to the northwards of Candia) has acted, and will continue to act, as a safety valve for this and other neighbouring islands. Like Mr. Forster, I have always hoped to have the chance of testing a cable at the moment when an earthquake is actually going on, but have not succeeded as yet. I have, however, frequently observed that for some hours before and after a shock there have invariably been magnetic disturbances on one or other of the cables (but principally on the Candia-Zante section). These disturb-

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ances show themselves by difficulties in working or (if I have been testing about that time) by violent vibrations on my usually very steady astatic galvanometer.

On April 2nd, I tested the Candia-Canea section at the same hour that Mr. Forster was testing that from Zante to Canea, and I find the following observations in my notebook:—

"Candia-Canea section. Insulation readings extremely unsteady. Light flying off scale every second. When line to earth at Canea vibrations still more violent. Galvanometer heavily shunted, but unable to get copper resistance at all."

I had also tested the Candia-Alexandria cable an hour before, and the insulation deflections were unusually unsteady and vibratory.

Shortly after midday we had a slight, undulatory shock of earthquake. This is the more unusual as it is the first case I remember, since my arrival in 1879, of Zante and Crete suffering from shocks on the same day. Candia seems to lay along a *separate* line of seismic force, as very frequently we feel shocks here which are not sensible in towns and villages twenty miles to the west and east of us, and whenever there has been a severe "quake" in Crete this town has always suffered the most. There seems to be some, as yet unsolved, relation between the lines of magnetic and seismic force.

Surely some of your readers who are stationed along the West Coast of South America, where earthquakes are the rule and not the exception, might furnish some interesting data on the subject.—Yours, &c.,

GEO. ALMOND, Supt. E. T. Company,
Candia, Crete, May 6, 1883.

ELECTRIC LIGHT FOR NOTHING.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Following up the very practical letter of "W. M." in your last issue, I should like to second that writer's remarks as to the wisdom of working for nothing. It has been my fortune or misfortune to have been not unfrequently accused to my face of having taken contracts at an unremunerative rate for the purpose of securing the market, and I have been accused of cutting the throat of the trade by so doing. I take this opportunity of stating that although my company has on its books probably more and larger contracts than any other single company, yet no single contract has yet been undertaken from which we do not secure a fair commercial profit. I would also add that I have frequently come across cases of large and important companies having offered to put in an installation free gratis, and experience is proving to me how suicidal is this policy, for its result is that of retarding sound business by encouraging intending purchasers to wait until they, too, like their more successful neighbour, get the light for nothing. Surely we may now fairly claim that electric lighting has got out of its long lived infancy, and is past the stage of mere experimentalism, and that this unhealthy practice of giving away is no longer needed.

Therefore I would urge all companies to buckle to in right earnest, and surely we shall find work in abundance far exceeding the capabilities of the united electrical industry of Great Britain. As a misapprehension has arisen as to who is the patentee of the new storage batteries manufactured by this company, I take this opportunity of explaining that the inventor is Professor Charles Forbes.—Yours, &c.,

J. EVANS JACKSON.
Electric Carbon, Storage, &c., Co., Leith, May 29, 1883.

AYRTON AND PERRY'S MOTOR.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: At the last Cantor lecture this season I exhibited to the Society of Arts a compact "half-horse" motor which Professors Ayrton and Perry had been good enough to lend, applying to it an E.M.F. of about 60 volts, from 29 Faure-Sellon-Volckmar cells; but I was able to stop the motor with one hand. This apparent failure of the machine was due to a resistance coil which had been added to it in order to prevent its racing itself to pieces when it was doing no work. By some oversight I had not been informed of the existence of this resistance, and consequently I did not remove it when testing the power of the machine. Under these circumstances it is not surprising that it refused to work as well as the De Meritens motor, which had no such artificial obstruction between it and the battery. I think it only fair to the patentees of the motor to make this explanation of an occurrence which they fear might otherwise have a damaging effect.—Yours, &c.,

OLIVER J. LODGE.
University College, Liverpool, 30th May, 1883.

INCANDESCENT LAMPS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: At page 26 of your issue of 26th inst. you mention an invention of Mr. C. F. Brush for preserving the filaments of incandescent lamps from "molecular bombardment."

I beg to inform you that the invention in question was anticipated by Mr. J. S. Beeman by his patent, No. 3279, of 11th July, 1882, under which he claims the use of mica, talc, glass, or other non-conducting material, as a possible support to the carbon filaments, and as a reflector and shield.

The specification describes that the mica support will act as a non-conducting diaphragm to arrest the deposit of carbon particles on either side or on various parts of the filament.

The patent in question is the property of this company.—Yours, &c.,

GEO. OFFOR.
The Consolidated Electric Company, 110, Cannon-street, London, E.C., 28th May, 1883.

THERMOPILES.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Can you or any of your readers inform me of the proportions of zinc and antimony used in making the alloy for the negative elements of Clamond's thermopile?—Yours, &c.,

C. D. S.
45, Savile Mount, Halifax.

TESTING LIGHTNING CONDUCTORS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: The letter of "T. L. P." in your last week's issue is a contribution in the right direction, and shows that good earth connections can be got for lightning conductors, where there is the skill to direct operations, and to determine accurately the electrical condition of the same. It would, however, be of additional value if he were to inform your readers whether he made his tests in the same manner as described for the General Assembly Hall, Edinburgh, viz., the having a testing wire temporarily connected with the point, so as to test the whole, conductor and earth. For the help of those who may want to test conductors, and who are away from verbal instruction, could he say in a comprehensive manner what battery power he employed, kind of instrument used for testing, say differential or Wheatstone bridge method of making earth for the test connections, &c., together with what assistance he needed. This would in some way compensate for the absence of any such matter in the Lightning Rod Conference Report, a fact much to be regretted, as in spite of constantly urging the value of good earth, and the necessity for tests, there is no word upon the "how" of testing, or a line to say whether 10, 20, or 50 ohms are safe margins. As doctors differ, so may electricians, and whilst one might insist upon a single ohm, others might, like Captain Bucknill, consider nearly a 1,000 ohm joint safe. It would be of much interest if at the close if this correspondence, your own views could be stated in an article.—Yours &c.,

May 29, 1883. GOOD EARTH.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: May I, through your columns, ask "T. L. P." to give me an insight into the manner of testing "earths" of as low a resistance as he describes, and the instruments he would use to get so accurate a result. Hoping he will give me the information I require.—Yours, &c., STUDENS.

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ELECTRICITY AS A MOTIVE POWER.*

BY PROFESSOR GEORGE FORBES.

(CONCLUDED FROM PAGE 43.)

Having now spoken of the applications of electricity to stationary engines, let us see what has been done, and what can be done, with respect to locomotives. There are two ways in which this application has been made. First, by storing the electricity in accumulators, and putting the accumulators in a tramcar, a boat, or a tricycle; and second, by deriving the current from a wire or other conductor placed along the line. The experiments made upon the first plan are very interesting, but their practical value is limited, owing to the weight and expense of the accumulators. I think that it would be far more economical to use compressed air engines. Ever since 1875, when I examined the compressed air tramcar of Scott Moncrieff, which ran so successfully in Glasgow, I have felt sure that this must become eventually the motive power for tramcars, and I have not yet seen anything to lead me to alter my opinion.

What has been done in the second way of proceeding? We will see that considerable progress has been made. At the Berlin Exhibition in 1879, Messrs. Siemens and Halske drove a train of a few carriages round a circular tramway, the gauge being three-quarters of a metre. In April, 1881, the same firm constructed the Lichterfelde and Berlin electrical railway, which is two miles long. One of the carriages of this railway was shown at the Paris Exhibition of 1881. The current is passed through the rails, which are insulated. It is then taken up by the wheels, and so passed through the motor. The motor turns at a very rapid rate, but it is geared to the wheels of the carriage by belting of wire-rope, which reduces the speed of revolution. The carriage has the appearance of an ordinary tramway-car, and the machinery is invisible. It was expected that snow might prove troublesome in such a system where the current is passed through the rails, but the winter of 1881-82 was so mild as to give no trouble. I have not heard whether any difficulty presented itself during the past winter. At the Paris Electrical Exhibition a somewhat similar car was used, but Messrs. Siemens were not allowed to pass the current through the rails, on account of the danger to horses, &c.; hence they were obliged to carry conductors, consisting of split tubes, on telegraph poles, and a small carriage fitting into the tubes made electrical contact with the motor on the car. Another electric railway has now been completed by the same firm, between Charlottenburg and Spandauer Bock. In this case also, a contact carriage is used, as at Paris. This line is three and a half kilometres long; two and a-half kilometres are level, but this line is specially interesting from the fact that a whole kilometre is on the considerable incline of 1 in 28. Messrs. Siemens have also applied the same principle to haulage in mines. A small electrical locomotive is used in a mine near Dresden to drive eight corves loaded with coal. Finally we have the electrical tramcar running on the Portrush line, in the North of Ireland, but this has been so well described in this room, and so recently, that I need only mention it.

It has always seemed to me that the principal advantage which would be gained by using electricity as a motive power for railway trains, lies in the great facility with which motive power could be applied to every wheel of the whole train. Captain Douglas Galton, in the concluding paragraph of his report on experiments, conducted by himself and Mr. Westinghouse, on continuous brakes, says :—The advantage which thus evidently ensues from utilising the adhesion of every wheel of a train, suggests the further consideration as to whether it would not be a more scientific arrangement, as well as being more economical in regard to the permanent way of railways, to utilise the adhesion of every wheel of a train for causing the train to move forwards, instead of depending for the moving force upon the adhesion of one heavy vehicle alone, viz., the locomotive."

Certainly there can be no doubt that it would save the permanent way from tear and wear, and the passengers from the shocks which are so unpleasant, but it is only by means of electricity that the proposition is practical; moreover, the movable parts of a locomotive are not perfectly balanced, and this limits the speed at which it can go. With an electrical motor the balance is perfect. By utilising a motor on every wheel you could go safely round curves at far greater speed. I feel sure that in this way it would be safe for trains to go at double the speed they do at present, and I hope to live to travel from London to Edinburgh in three and a half hours, smoothly, and without jolting. Furthermore, a train, instead of taking several minutes to get up full speed, could do so in a few seconds. This follows from the same reasoning as is applied to continuous brakes. Lastly, if there were power enough, a train could go up a steep hill instead of being confined, as practically they are, to an inclination of 1 in 80. In a district with heavy goods traffic, this might be a great advantage.

These considerations appear to me to be so important, that I must pause a while to make them clear.

First.—As to getting up speed quickly. With an ordinary train, weighing ten times as much as the engine, the theoretical minimum of time required to get up a speed of thirty miles an hour is one minute, however powerful the engine may be. The reason is that the wheels would slip if the motion were accelerated more rapidly. But if power were applied to every wheel, it would have a speed of 30 miles an hour in six seconds, and with no more jerk than is now felt when a continuous brake is applied.

Second.—As to the going up hill. The same advantage here is gained as would be gained by continuous brakes. An ordinary train, when the lines are in an average condition, slips down an incline of 1 in 50, when the locomotive alone is braked. You all remember the sad accident the other day in the Rocky Mountains from this cause. But when all the wheels are braked, the train rests on an incline of 1 in 5. So also, if we had the power, we could ascend an incline of 1 in 5 by electrical motors.

Third.—As to advantage to permanent way. The engine does not give a steady pull at all times to all parts of the train. In fact, in going round a curve, part of the engine's power is used up in trying to pull part of the train off the lines. With power applied to all the wheels, this would not be so. Moreover, the enormous weight of the locomotive, imperfectly balanced, which is the chief source of mischief, would be done away with.

Fourth.—As to cost. The cost of making an ordinary railway line with tunnels, embankments, bridges, viaducts, &c., in England, may be taken at £15,000 a mile; but if it goes up inclines instead of having expensive engineering works, the cost will be the same as making it on a level, *i.e.*, £5,000; and hence, on a goods line, the cost of construction might be reduced to one-third. This original outlay is a far more serious matter than the working expenses of a railway (of which the cost of the traffic is 26 per cent.); so that, even if by using electricity you increased your working expenses you might still be making a great saving on the whole. On fast passenger trains the power to drive your trains at twice the speed would counterbalance any small loss of economy.

There are many cases where such an application of motive power would be peculiarly satisfactory. The most important of these is the Underground Railway in our city. It is now universally admitted that steam locomotives vitiate the air to an intolerable extent. If motive power were used electrically, this evil would be avoided. Moreover, a line like this, which is almost totally underground, and is comparatively unaffected by snow or rain, possesses exceptional advantages for electrical insulation. But the system which I have advocated would introduce special advantages to this line. What are the conditions of working? The distance between stations is so short that a great deal of time is wasted in getting up speed and stopping the trains. The latter evil, it is true, has been reduced to a minimum by the adoption of continuous brakes; but you will understand how much speed is limited by the former consideration, when I tell you that an ordinary train cannot get up a speed of thirty miles an hour until it has passed over a quarter of a mile, just about the distance between some of the stations. If the system I propose were adopted of applying motive power to every wheel, the same speed would be attained in forty-four yards.

The Channel Tunnel, when completed, will be specially favourable for the insulation of conductors. But the system which I recommend could not be adopted, as the great advantage of the tunnel is that the same waggons will go right through without any transference of goods. In this case, if electricity be used as the motive power, it would be necessary to use it to drive a heavy locomotive.

I think I have now said enough to prove that a great deal has already been done, and that we may reasonably expect a great deal more to be done in the use of electricity as a motive power. Water-power has been usefully employed in various installations, to obtain electricity, and the current has been successfully conveyed several miles, to be reconverted into motive power with great economy, and electric railways have been successfully and economically worked by electricity. I have not thought it right in this lecture to indulge in Utopian dreams of what may be done in the future, however pleasant such an exercise of the imagination might have been. I have thought it to be more useful to look at the matter from a practical point of view, and to estimate our present position with respect to this force, and to indicate the steps which our past experience would warrant us in taking in the immediate future. I should like to see a larger number of our wealthy compatriots experimentalising in this field, so as to keep our country in the front rank of the applications of electricity, as she always has been in those of steam. But we must go on step by step—learning from every fresh experiment, and utilising experience for further advances.

* Paper read before the Society of Arts on Wednesday, May 2, 1883.

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THE ELECTRICIAN.

TO CORRESPONDENTS.

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We cannot undertake to return drawings or manuscripts, and must, therefore, request Correspondents to keep copies.

ANSWERS TO CORRESPONDENTS.

A. A. CAMPBELL-SWINTON.—*You will find a description of the Ferranti armature in Patent No. 3419, dated 18th July, 1882, and granted to S. Z. de Ferranti and A. Thompson. Price 6d. You can obtain a copy of it at the Commissioners of Patents Sale Department, 38, Cursitor-street, Chancery-lane, W.C.*

VARIOUS CORRESPONDENTS.—*Owing to the numerous reports of meetings in this week's issue we are compelled to hold over letters from Messrs. Mordey, Kennelly, M. A. Bandsept, and others.*

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PROF. HUGHES ON MAGNETISM.

The invention of the telephone gave rise to an unusual amount of attention being concentrated on magnetic phenomena. More recently their application to the production of electrical currents for illuminating purposes has increased their practical significance, and rendered a trustworthy explanation, or serviceable working theory, much sought after. Two of, perhaps, the most startling, as well as most interesting, papers ever read before the Society of Telegraph Engineers and of Electricians have been devoted to this subject by men whose reputation in the field of experimental scientific research justifies the belief that their conclusions have, at all events set the theory of magnetism on a sounder basis than it had previously enjoyed. We refer, of course, to Mr. Stroh's remarkable illustrations thirteen months ago, and to Professor Hughes's experiments last Thursday week. With two such indefatigable and adroit inquirers as these busily interrogating magnetism as to what it really is, a true answer cannot long be withheld.

Not that anybody expects a very complete answer to the question, though we may get one that is true so far as it goes. But it is one thing to be content with an approximate answer, and another to treat all such questions as idle. What is electricity? what is magnetism? are questions which are often contemptuously set aside as unprofitable, we suspect, only because the answers have not been easily forthcoming. In the absence of precise knowledge we make believe to be satisfied with fanciful theories—theories which have had to shift and be remoulded with every fresh extension of our acquaintance with phenomena. If a history of theories ever comes to be written, it will be one long satire on the rashness and vanity of human speculation; consequently, it will probably never be written, for the only people specially concerned would find it very humiliating reading. Theories relating to the unknown have a chance of living just so long as the known facts are in accord with them; fresh theories have then to be propounded, which again receive their quietus with the last new discovery. All this is perfectly natural and quite inevitable; only what would strike the historian as exceedingly odd is that the course of science, which is nothing if not exact, is just as thickly strewn with exploded theories—superstitions one may almost call them—as metaphysics and theology. The substantial service rendered by men like Bjerkness, Stroh, and Hughes, is that they add immensely to the sum of our knowledge of facts. If they do not tell us what the thing is, they show us more precisely what it does, or at all events what it seems to do; and they sweep away a host of conflicting and confusing conjectures which have ceased to be of any practical utility.

This last, in the opinion, we think, of most of his audience was what Professor Hughes succeeded in doing the other evening. Popular text books would have to be remodelled under the new light thrown on the phenomena of magnetism. This was the general impression created by a series of experimental demonstrations, the novelty of which was undeniable. It does not follow, however, that the theory advanced by the ingenious professor is itself a final one. It fits the new facts, and, to use his own words, "in every portion allows at least experimental evidences of its probable truth." It is, one may cordially admit, a more consistent theory than any yet advanced, and, granting that theorising was necessary for the occasion, a highly valuable addition to the list. But it is possible, just possible, the facts may fit equally well, or even better, with some other theory still to be advanced. Microphonic phenomena are none the less instructive because nobody can agree in explaining them; and these novel discoveries relating to the behaviour of magnetism will bear fruit all the same, whether the discoverer's explanation be the right one or not.

It is natural we should couple the two papers together, one by Mr. Stroh and the other from Professor Hughes; but they differed very greatly in their treatment of the subject. The first, although following up a consistent line of investigation, which in itself implied a definite perception of what was likely to happen, scarcely ventured on the domain of theory at all—thus and thus the phenomena are shown to act; I do not know the cause; I will not hazard a guess. The other, though setting to work in much the same spirit felt constrained, apparently as a matter of conscience, to formulate a theory to account for them, lest, perhaps, people should doubt the facts. We need not share, though we may sympathise with these apprehensions. Many people will repeat Professor Hughes's experiments; they will, in all probability, furnish an absorbing subject of experimental verification for some time to come. His discoveries will be confirmed, and fresh ones probably contributed; but it will greatly surprise us if the explanation from all quarters tallies with that of the experimenter-in-chief. If it is alleged that you must have a theory, a working theory, for every-day use, the reply is, if you must, you must, but you will be very apt to go wrong upon it. Only the other day two eminent professors were seen inquiring what was the most efficient form of magnetic motor. Theory, of which they are credited with a quite adequate stock, apparently did not supply the answer; they had to test a number of motors of varying sizes and weights in order to discover their relative powers. Any working man could do that without a theory. Perhaps Pro-

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fessor Hughes would retort that this only proves the necessity for some guiding principle on which we may safely make our calculations. It certainly does prove the desirability, but the necessity is not so self-evident; and, at all events, there is no necessity for hurry. Accumulate facts by all means, and from the recesses of nature as far as you can probe them; but the only durable theory in the long run will be that which formulates itself when all the phenomena are known.

It would be premature to offer any observation in the way of serious criticism on Professor Hughes's theory. But as regards the facts, it will be noticed that he has paid a great deal of attention to what takes place inside the magnet, previous researches having dealt mostly with what takes place outside it. Perhaps the peculiar merit of his experiments, the most important of them, was that they brought into greater prominence the action of the earth's external magnetism upon magnetic metals. It probably is the case that the molecules of soft iron are freer to move than those of hard steel, but it still remains to be answered why if they are freer to move they are not also freer to stop where they have been moved to. Why should they move to their old position instead of stopping where the earth's magnetism transiently directed them? Further, there were certain magnetic actions so like electrical phenomena brought out in the course of his paper that the reader is surprised Professor Hughes did not make more of them. Magnetism and electricity are so nearly related that every point of identity deserves to be carefully noted, tested, and demonstrated with the keenest interest. No one could fail to see that Professor Hughes's mallet and his torsion appliances often did duty for an electrical current.

THE CAUSE OF EVIDENT MAGNETISM IN IRON, STEEL, AND OTHER MAGNETIC METALS.*

The extreme sensitiveness of the induction balance to all molecular changes in the structure of metals was remarked in my first paper on this subject to the Royal Society;† and in the case of iron and steel it is most remarkable, as the addition or subtraction of $\frac{1}{300000}$ part, or the addition of the smallest iron filing to an already large balanced mass of iron, is at once rendered evident and measurable.

Possessing such an invaluable instrument of research, I was desirous of investigating the molecular construction of iron and steel, but at once I met with a difficulty, viz., that magnetism itself completely changed the character of any piece of iron under investigation; consequently, finding no help or explanation of the effects produced from any accepted theories of magnetism, I was forced to investigate, by means of the induction balance, the whole question of magnetism as existing in the interior of a magnet, and to determine the particular structure for each case, such as neutrality and polarity.

In a recent paper to the Royal Society, upon the theory of magnetism,‡ I described the use of and demonstrations obtained by the induction balance. In this paper I propose to confine myself to demonstrations that can be repeated without it, and whose effects can be observed by the aid of ordinary magnetic direction needles.

That magnetism is of a molecular nature has long been accepted, for it is evident that, no matter how much we divide a magnet, we still have its two poles in each separate portion, consequently we can easily imagine this division carried so far, that we should at last arrive at the molecule itself possessing its two distinctive poles, consequently all theories of magnetism attempt some explanation of the cause of this molecular polarity, and the reason for apparent neutrality in a mass of iron.

Coulomb and Poisson assume that each molecule is a sphere containing two distinct magnetic fluids, which in the state of neutrality are mixed together, but when polarised are separated from each other at opposite sides; and, in order to explain why these fluids are kept apart as in a permanent magnet, they had to assume, again, that each molecule contained a peculiar coercive force, whose functions were to prevent any change or mixing of these fluids when separated.

There is not one experimental evidence to prove the truth of this assumption; and as regards coercive force, we have direct experimental proof opposing this view, as we know that molecular rigidity or hardness, as in tempered steel, and molecular freedom or softness, as in soft iron, fulfil all the conditions of this assumed coercive force.

Ampère's theory, based upon the analogy of electric currents, supposes elementary currents flowing around each molecule, and that in the neutral state these molecules are arranged haphazard in all directions, but that magnetisation consists in arranging them symmetrically.

The objections to Ampère's theory are numerous. 1st. We have no knowledge or experimental proof of any elementary electric currents continually flowing without any expenditure of energy. 2nd. If we admit the assumption of electric currents around each molecule, the molecule itself would then be electro-magnetic, and the question still remains, What is polarity? Have the supposed electric currents separated the two assumed magnetic fluids contained in the molecule, as in Poisson's theory? or are the electric currents themselves magnetic, independent of the iron molecule?

In order to produce the supposed heterogeneous arrangement of neutrality, Ampère's currents would have either to change their position upon the molecule, and have no fixed axis of rotation, or else the molecule, with its currents and polarities, would rotate, and thus be acting in accordance with the theory of De la Rive. 3rd. This theory does not explain why (as in the case of soft iron) polarity should disappear whenever the exciting cause is removed, as in the case of transient magnetisation. It would thus require a coercive force in iron to cause exactly one-half of the molecules to instantly reverse their direction, in order to pass from apparent external polarity to that of neutrality.

The influence of mechanical vibrations and stress upon iron in facilitating or discharging its magnetism, as proved by Matteucci, 1847, in addition to the discovery by Page, 1837, of a molecular movement taking place in iron during its magnetisation, producing audible sounds, and the discovery by Dr. Joule, 1842, of the elongation of iron when magnetised, led De la Rive, in his remarkable "Treatise on Electricity," 1853, to give his theoretical views upon magnetism in the following remarkable words:—

"The whole of the magnetic molecular phenomena that we have been studying lead us to believe that the magnetisation of a body is due to a particular arrangement of its molecules, originally endowed with magnetic virtue, but which in the natural state are so arranged that the magnetism of the body that they constitute is not apparent. Magnetism would, therefore, consist in disturbing this state of equilibrium, or in giving to the particles an arrangement that makes manifest the property with which they are endowed, and not in developing it in them. The coercitive force should be the resistance of the molecules to change their relative positions."

Wiedermann, in 1861, gives a theory in which he admits the fluids of Poisson, or the elementary currents of Ampère, as the cause of polarity of the molecule, but belives that the molecules are turned in a general direction in the case of polarity, and that in neutrality, like Ampère's, the magnetic axes of the molecules are turned in all directions.

Maxwell, in his remarkable treatise on "Electricity and Magnetism," 1881, page 77, gives the following *résumé* of Weber's theory:—

"Weber's theory differs from Poisson's, in assuming that the molecules of the iron are always magnets, even before the application of the magnetising force, but that in ordinary iron the magnetic axes of the molecules are turned indifferently in every direction, so that the iron, as a whole, exhibits no magnetic properties." And again, page 429, Maxwell says he agrees with Weber's views, and that neutrality, or unmagnetised iron, has the axes of its molecules placed indifferently in all directions, and that the act of magnetisation consists in turning all the molecules so that their axes are either rendered all parallel to one direction, or at least deflected in that direction.

I have quoted these several theories which admit of the inherent polarity of the molecule, and in that respect they entirely agree with my own; but the induction balance at once shows that they are erroneous in the most important part, for my researches have proved that neutrality is perfectly symmetrical, that there is no case of neutrality where the axes of the molecules are turned indifferently in all directions, and that we cannot obtain perfect neutrality except when the molecules form a complete closed circuit of attraction.

I believe that a true theory of magnetism should admit of complete demonstration, that it should present no anomalies, and that all the known effects should at once be explained by it.

* Paper read before the Society of Telegraph Engineers and of Electricians by Prof. D. E. Hughes, F.R.S., Vice-President, May 24, 1883.

† "On an Induction Current Balance, and Experimental Researches made therewith."—*Proceedings Royal Society*, March 29, p. 56, 1879.

‡ *Proceedings Royal Society*, May 10, 1883.

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From numerous researches I have gradually formed a theory of magnetism entirely based upon experimental results, and these have led me to the following conclusions :—

1. That each molecule of a piece of iron, steel, or other magnetic metal is a separate and independent magnet, having its two poles and distribution of magnetic polarity exactly the same as its total evident magnetism when noticed upon a steel bar-magnet.

2. That each molecule, or its polarity, can be rotated in either direction upon its axis by torsion, stress, or by physical forces, such as magnetism and electricity.

3. That the inherent polarity or magnetism of each molecule is a constant quantity like gravity; that it can neither be augmented nor destroyed.

4. That when we have external neutrality, or no apparent magnetism, the molecules, or their polarities, arrange themselves so as to satisfy their mutual attraction by the shortest path, and thus form a complete closed circuit of attraction.

5. That when magnetism becomes evident, the molecules or their polarities have all rotated symmetrically in a given direction, producing a north pole if rotated in that direction as regards the piece of steel, or a south pole if rotated in the opposite direction. Also, that in evident magnetism, we have still a symmetrical arrangement, but one whose circles of attraction are not completed except through an external armature joining both poles.

6. That we have permanent magnetism when the molecular rigidity, as in tempered steel, retains them in a given direction, and transient magnetism whenever the molecules rotate in comparative freedom, as in soft iron.

Experimental Evidences.

In the above theory the coercive force of Poisson is replaced by molecular rigidity and freedom; and as the effects of mechanical vibrations, torsion, and stress upon the apparent destruction and facilitation of magnetism is well known, I will, before demonstrating the more serious parts of the theory, cite a few experiments to prove that molecular rigidity fulfils all the requirements of an assumed coercive force.

The influence of vibrations, torsion, or stress of any kind upon a magnetised steel or iron rod may be seen by striking with a wooden mallet rods of hard and soft steel, also hard and soft iron previously magnetised to a known degree. The tempered steel, owing to its molecular rigidity, will lose but 5 per cent., the soft steel 60, hard iron 50, and soft Swedish iron 99 per cent. of its magnetism, the amount of loss depending not so much upon whether the metal be steel or iron, as upon its degree of hardness and softness; and as hard steel requires far more power to magnetise it to the same force than iron, it is possible to imagine a steel so hard that its molecules could not rotate, and that, consequently, no magnetism could be manifested from a given inducing cause, whilst a perfectly soft iron would give the maximum effect and instantly return to its previous state. From this we might, in error, suppose that soft Swedish iron could not retain its magnetism, and that its natural state would be zero, or neutrality. The apparent disappearance of magnetism, however, is here due to the extreme freedom of motion of its molecules allowing them at once to follow the comparatively feeble directing force of the earth's magnetism. We can demonstrate this by feebly magnetising a rod of soft iron held vertically, so that its north pole is at the lower portion. Upon removing the inducing magnet, or electro-magnetic coil, we find that the rod retains a powerful north polarity, but if magnetised in a contrary sense then we have only *traces* of magnetism left upon the withdrawal of the inducing cause. To succeed in this experiment, as in all others where soft iron is mentioned, we should use the best Swedish charcoal iron, thoroughly annealed at high temperature.

We find, again, that rods of steel or iron will lose far less magnetism when vibrated in the magnetic dip, or vertically, when their north poles are at the lowest extremity, than when horizontal, or still less than when their poles are contrary to those of the earth's field, and also that they will acquire their maximum magnetism from a given exciting cause when held vertically as described, and the molecules allowed greater freedom of motion to obey the directing influence by vibrations, torsion, stress, or blows upon the iron. Any influence that would tend to give greater freedom of motion, such as heat or mechanical trepidations, gives a far higher magnetic force to the iron than could be obtained without these aids.

In order to render visible the effects of motion upon magnetism, we may take two glass tubes, or ordinary phials, of any length or diameter, say 10 centimetres in length by 2 centimetres in diameter. If we now put iron filings in these tubes, leaving about one-third vacant, so as to allow complete freedom in the filings when shaken, we find that each tube, when magnetised, retains an equal amount of residual magnetism, and that this all disappears upon slightly shaking the tube. We are thus imitating the effects of vibration. But if in one of these tubes we pour melted resin (in fact, any slightly viscous liquid, such as petroleum, suffices), we then render these filings more rigid, and then we can no longer produce by shaking the disappearance of its residual magnetism. In pouring in petroleum we have apparently been introducing a strong coercitive force, but we know that it can only have the mechanical effect of rendering the iron filings less free to turn, and so comparatively rigid. If we desire to see the effect of torsion, we have only to shake the filings so that when the tube is held horizontally the vacant space is above, and rotate it slightly (but without shaking) about a horizontal axis. Its remaining magnetism instantly disappears upon rotation, although we evidently have not changed the longitudinal position of its particles. A similar effect takes places upon a soft iron rod, for if we magnetise it and observe its remaining magnetism, we find that, upon giving a slight torsion to this wire, its remaining magnetism instantly disappears—a similar effect to that in the rotating tube of iron filings. But if the iron is rendered more rigid by hammering, or steel rendered hard and rigid by tempering, torsions or vibrations have but little effect, as in the case of the filings rendered rigid as above mentioned. Thus we have no longer need of an assumed mysterious coercive force to account for the retention of magnetism, for once knowing the mechanical qualities of iron and steel, and their degree of molecular rigidity or hardness, we can at once predict their retentive magnetic powers.*

Rotation of Inherent Polarised Molecules.

Torsion, as well as mechanical vibrations, has, as we have seen, a powerful influence in aiding the molecules to overcome their inertia, and thus aid them to rotate in the direction of the inducing influence; and we may thus polarise strongly a flat soft iron rod by simply bending or vibrating it when held vertically, and if we measure the magnetic force obtained we shall notice that the force is strictly relative to the degree of softness of the iron. Thus, with hard steel we should obtain only *traces* of polarisation, whilst with extremely pure soft Swedish iron we obtain the maximum of force. The bar of iron or steel, being held in the earth's magnetic field, of infinite size compared with the bar, and infinitely homogeneous, cannot deflect or weaken its surrounding field. Its lower portion being north, apparently strengthens it by its reaction, whilst its upper, south, apparently weakens the field; but, as Maxwell has shown, "the two poles of each molecule are equal and opposite, consequently the sum of each molecule and the whole mass must be zero."

We have a far greater induced polarity in iron or steel when the iron is in thin bars or small wires, and this we should expect, as the external molecules rotate directly under the influence of the earth's magnetism, whilst those forming the interior of the bar either rotate feebly, or, as in the case of very thick bars, actually act as an armature, preventing, by their influence, free rotation of the exterior molecules.

Thus, as the sum of the two and equal polarities in a bar of iron is zero, it is evident that its polarity must be inherent. I have some remarkably pure soft Swedish iron wire, one millimetre in diameter, and as its inherent polar force seemed great when held vertically in the earth's magnetic field, I measured in the induction balance this force compared with a similar column of the magnetic atmosphere which it displaced. The inherent polarity of this wire, simply rendered evident by the earth's magnetism, was 15,000 times greater than the column it displaced.

We cannot, either by induction, conduction, or concentration, produce a greater force in another body of similar displacement or size, otherwise we could easily create power from a feeble source. Thus, the enormously greater magnetic power observed in iron than the same column of air which it displaces must be due to the *inherent* polarity of its molecules.

Amongst numerous bars of iron upon which I have experimented, one of ordinary hoop-iron, 2 centimetres wide, 40 centimetres long, and 1¼ millimetre thick, not softened, possesses sufficient molecular rigidity to be apparently uninfluenced by earth's magnetism. When this rod is rendered neutral, we have but feeble polarity—mere traces when it is held vertically under the earth's magnetic influence; but if we apply a few successive torsions or vibrations to it when thus held, we have at once several thousand times greater polarity than before. Now, if iron had the power of deflecting or concentrating the earth's magnetism upon itself, it should not require the mechanical aid to molecular rotation given to it by these torsions or vibrations. Thus we are forced to conclude at least the existence of the inherent

* "On the Molecular Rigidity of Tempered Steel," by Professor D. E. Hughes, F.R.S.—*Proceedings Institution of Mechanical Engineers*, pages 72—79, January, 1883.

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polarity of the molecules; and, if we admit this, we must also, as a necessary consequence, admit the rotation of these molecules, else we cannot explain why mechanical vibrations allowing freedom of motion should always produce the polarity in accordance with the directing cause. I have already shown that torsion and vibrations *per se* are apparently destructive of magnetism; consequently, in this case Poisson's two fluids and Ampère's parallel currents should, according to their theory, be mixed or heterogeneous, whilst according to the views I am sustaining the polarised molecules should obey, as compass needles, any magnetic directing cause whenever sufficient molecular freedom of motion allows free rotation.

The inherent polarity of iron may again be observed by drawing a flat rod of soft iron over one or both poles of a permanent magnet. This rod will then be powerfully magnetised, its remaining magnetism, when separated from the magnet, being sufficiently powerful to strongly deflect a suspended direction needle. A few slight torsions or vibrations will then completely discharge it. Now, suppose this operation repeated successively many thousand times, if there was no inherent polarity we should have gradually drawn all the polarity out of the magnet, and discharged it into the atmosphere. Nothing of the kind takes place. The molecules of the iron are simply rotated each time, and the only energy in work expended or lost comes from the arm of the experimenter, and the energy required would be strictly in accordance with the molecular freedom, or softness and hardness of the iron and steel; thus, whilst soft iron could be easily polarised and discharged by mechanical torsions, hard-tempered steel would require a far greater amount.

Dr. Warren De La Rue, F.R.S., kindly aided me in this part of the research by passing a current from his well-known chloride of silver battery through iron and steel wires. A condenser of 42·8 microfarad capacity, charged by 3·360 cells, was used. We passed this enormous electric charge longitudinally through the wires, and observations were made as to whether any change whatever was produced in their quality or inherent polarity, the result being that these wires gave exactly the same magnetic polarity from a given directing or inducing cause as before, being similar in nature and degree; consequently, this enormous electric force had not changed or destroyed the original inherent polarity.

If the molecules possess inherent polarity and rotate upon their axes, similar to a series of compass needles having a slight degree of frictional rigidity, then, upon passing one pole of a magnet above them, they would turn symmetrically in one direction, and drawing the same pole of the magnet in the contrary direction would rotate them, and they would then remain symmetrically in the opposite direction.

A precisely similar effect takes place in a soft iron rod, placed east and west a few inches above a direction needle. Upon drawing the south pole of a powerful natural magnet at a few centimetres distance above the wire from east to west, the north polarities of the molecules successively turn in the direction of west, following the attraction of the south pole, as previously seen on the small compass needles. The rod is now magnetised with its north pole west, as indicated by the direction needle below any portion of this rod. Upon passing the same south pole of the natural magnet in a contrary direction, the molecules all rotate, their north poles still turning successively to the south pole of the permanent magnet until its arrival at the end from which the first magnetisation commenced. The rod has now entirely changed its polarity, and its north pole is east.

This phenomenon is well known in the ordinary magnetisation of rods, where care is taken to draw the magnet always in a similar direction, or the poles would be reversed at each to and fro drawing. To account for this, on Coulomb-Poisson's theory, it would be requisite that—first, all the fluids be separated with their north fluids symmetrically in one direction, but on drawing back the magnet, these fluids would have to mix together, the north fluid passing through its south fluid to be finally opposite to its previous position, its coercive force doing the double work of allowing both fluids to mix and pass through each other, and finally keeping them entirely apart. Ampère's theory would require that from a haphazard arrangement the molecules should become symmetrically arranged upon the first passage of the magnet, then upon its reversed direction one half of the electric elementary currents should successively revolve in a contrary direction to arrive at neutrality before, finally, the other half followed the direction of the first half, and now all these currents would be revolving in the opposite direction to that upon the first magnetisation. We thus see that both these theories, whilst resting altogether upon assumption, are extremely complicated and improbable.

We might suppose, from the theory which I am advocating, that upon the rotation of the molecules there would be some disturbance or mechanical trepidation; and such is found to be the case, as first observed by Page, and afterwards verified by Dr. Joule and De la Rive, in the molecular sounds produced in iron upon its magnetisation. Reis's first telephone was founded upon these sounds, and Du Moncel has made numerous researches upon this subject.

In the last of my experiments cited, the sounds are too feeble to be heard, but by the application of the microphone these trepidations at once become audible.

That molecules of iron and other metals rotate with time, whose period becomes shortened by mechanical vibrations, is well known in metallurgy, the ultimate result being generally the passage from a fibrous condition, as in iron wires, to a high degree of crystallisation. For many years I employed a circular vibrating spring as the regulator of speed of my printing telegraph instrument, and although this spring was so regulated by means of a frictional break, or "Frein," as not to surpass its limits of elasticity, these springs were constantly breaking after a few days' use, and, as a matter of urgent necessity, I made special researches into the cause of this breaking after a few days constant vibratory action. I found at the point of rupture a high state of crystallisation. Fibrous iron would thus become thoroughly crystallised and break in one day; the number of vibrations for an instrument in constant use during 24 hours being 1,209,600. Thus we could roughly estimate the life of iron in the form of one of these springs at one million vibrations. Copper crystallised in one hour, and all metals and alloys were inferior to steel, except aluminium bronze. The latter springs would stand six weeks' constant use, or some fifty millions of vibrations. I finally resolved this problem by spreading the amount of vibrating work over a spiral spring containing three metres of steel rod wound into the same space as previously held by the straight rod of 30 centimetres; by this means the average life of these springs has become five years. Evidently the molecules of these fibrous springs must have rotated under the vibrations, in order to produce crystals. The same phenomenon is observed in axles of carriages receiving constant trepidations, large crystals being always found at the point of fracture. Again, if we rapidly magnetise and demagnetise an iron rod, we have the production of evident heat, due to the constant motion of its molecules.

Maxwell describes an experiment of Beetz, in which an exceedingly small filament of iron was deposited by electrotype, under the influence of a strong magnetic field, in order to arrive at the inherent polarity of comparatively few molecules, and, as its magnetic force was very great, he regards the experiment as conclusive. My own experiments show that we have far less external magnetic force from a solid bar than from a thin tube or flat bar of the same surface exposed to a limited exciting cause. We know that magnetism does not penetrate to a very great depth, and we also know that, if to a thin steel permanent magnet we place another piece unmagnetised, or, better still, a rod of soft iron, its external polarity is greatly reduced; consequently, the external evidence of polarity is not a direct measure of the degree of rotation, nor of the total inherent polarity of its mass. We may have a great superficial *external* rotation superposed upon rotations of an opposite nature, as will be seen later; and thus the internal molecules of a magnet often act more or less as an external armature in closing its circle of attractions.

I have stated my belief that the molecule itself possesses its inherent polarity, which, like gravity, is an endowed quality for which we have no more reason to suspect the cause to be elementary electric currents than that elementary currents should be the cause of gravity, chemical affinity, or cohesion and its polar power of crystallisation, most of which are affected by an electric current. We have a certain analogy between electric currents and magnetism, but not so great as the analogy between the magnetic polarity of a molecule and its other endowed qualities.

Magnetism, like chemical affinity, cohesion, and crystallisation, has its critical points. Faraday discovered that at red-yellow heat iron instantly lost its apparent polar magnetic power, to be as instantly restored at red heat, the critical point varying in iron, steel, &c., and being the lowest in nickel. This would be difficult to explain upon Ampère's theory, as we should have to admit the instant destruction or cessation of the elementary currents, to be again restored at a few degrees less temperature. It would be equally difficult to explain under my view, if it did not belong to a whole class of phenomena due to the possession by the molecules of various endowed qualities, of which chemistry and all our means of research can only teach us their critical points, without attempting to explain why, for instance, iron has a greater affinity for oxygen than gold. We know that it is so; we know that the molecules of all matter are endowed with certain qualities having certain critical points, and I can see no reason for separating their magnetic inherent polarity from their numerous other qualities.

(TO BE CONTINUED.)

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PRACTICAL TELEPHONY.

(CONTINUED FROM PAGE 35.)

CONNECTING-UP INSTRUMENTS.—Fig. 5 shows the connecting

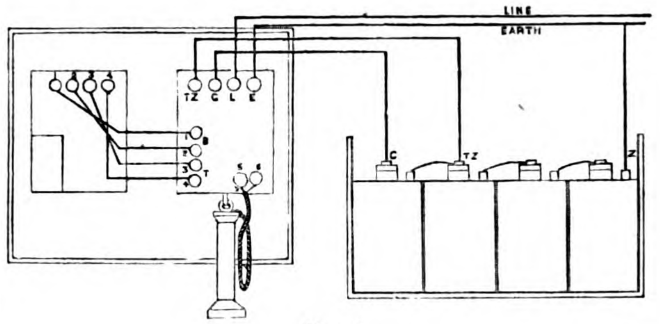

FIG. 5.

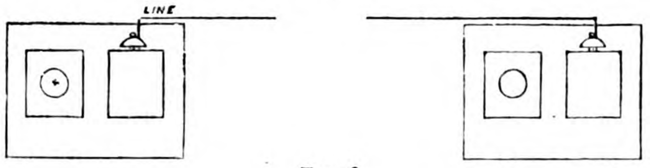

FIG. 6.

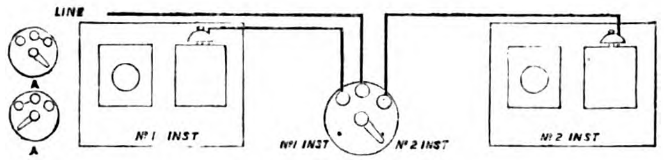

FIG. 7.

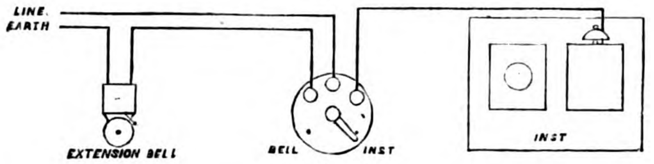

FIG. 8.

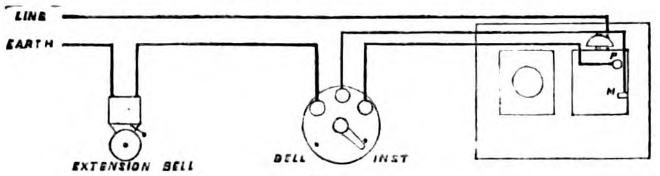

FIG. .

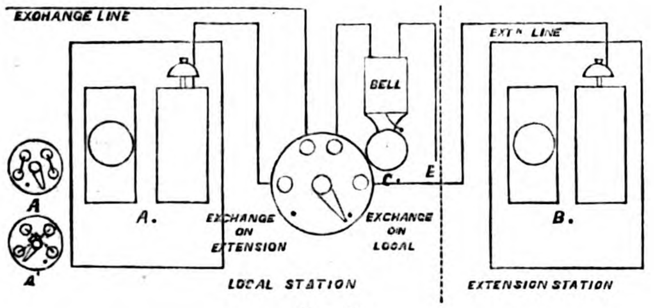

FIG. 10.

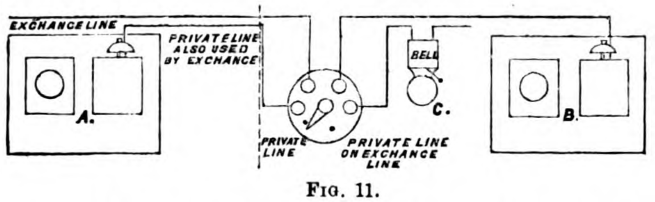

FIG. 11.

wires and connections for a single station, consisting of battery, switch bell, Blake transmitter, and telephone, which is the arrangement in most general use. Care must be taken to follow the instructions for setting the battery in action and joining it up, also the remarks concerning stripping and cleaning the joining-up wires and soldering connections or joints. Having mastered the detail of connecting up a single station, the next step is fitting up a simple private line, as shown in Fig. 6. It has not in Fig. 6 been deemed necessary to give all the details of connections for joining

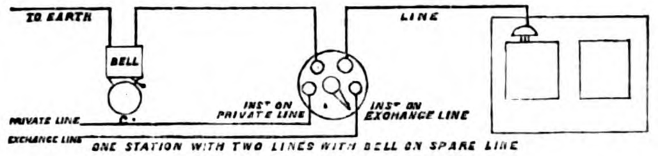

FIG. 12.

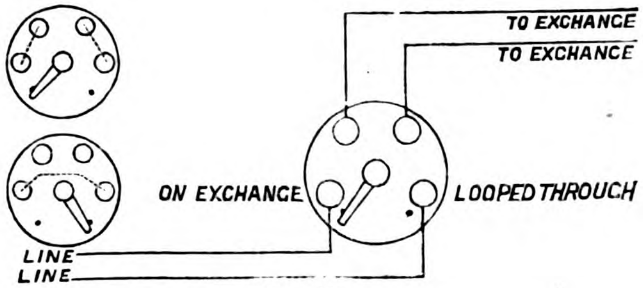

FIG. 13.

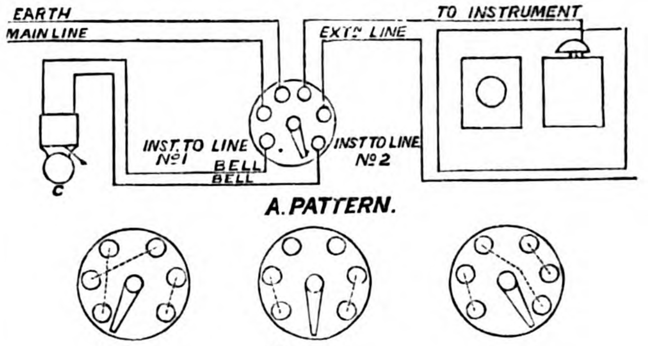

FIG.

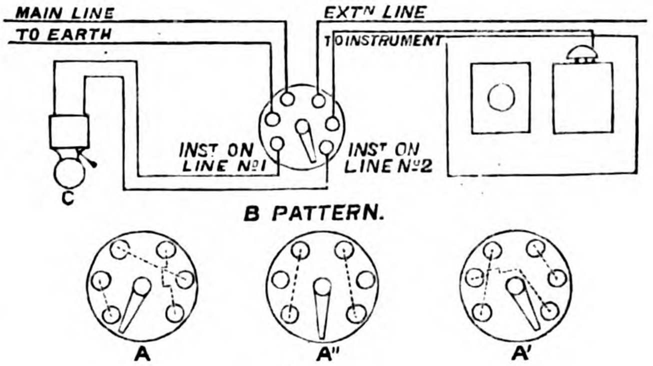

FIG. 15.

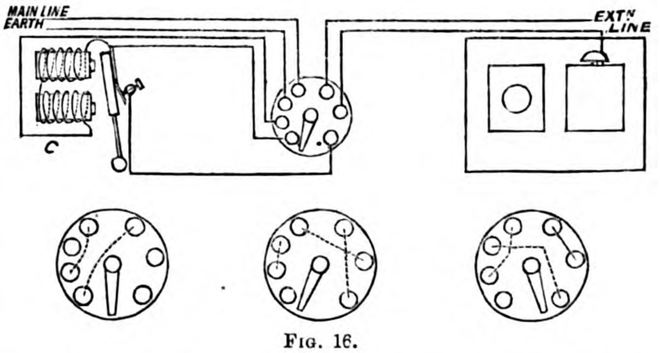

FIG. 16.

up a single station, as they are supposed to be known from the arrangement given in Fig. 5. The use of the various switches will be found explained further on. A list only of the requirements the various arrangements are contrived to meet will now be given.

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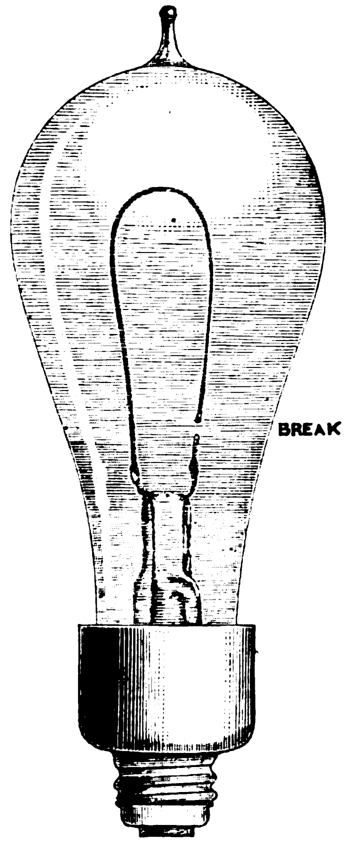
EXCHANGE ON PRIVATE LINE WITH TWO STATIONS AT ONE END IN DIFFERENT OFFICES OR ROOMS.—The switch should be placed near the instrument in most frequent use, as shown in Fig. 7. When with one instrument there is an additional bell placed where required to call attention to the instrument the switch should be near the instrument, as shown in Fig. 8. An improved arrangement of this kind is shown by Fig. 9. When the exchange line is extended, or requires a switch to be arranged to prevent the extension being used as a local private line, the handle must be kept to the right, as shown in Fig. 10. When it is required to use a private line as part of an exchange line, connected so that the private line station nearest the exchange can only speak on the private line, and not to the exchange, the bell should be connected so that the exchange can send a signal to be connected to private line when required, and the handle must be kept to the left, as shown in Fig. 11. When we have exchange and private lines running to one instrument, with an extra bell on the line that at the time is disconnected from the instrument, but so that the private line shall not be able to be connected through to exchange lines, the arrangement is as shown in Fig. 12. With two wires running into the exchange, and requiring to be put through at night, the arrangement is as shown in Fig. 13. When two lines have to be arranged in order to allow the intermediate station to speak up or down, or to be put through (the intermediate being then cut out, leaving only a bell in circuit), the arrangement is as shown in Figs. 14 and 15. Fig. 16 shows the same, but the switch converts the trembling bell C into a single stroke when in central position.

The extra sketches of the switches in certain of the above figures, with dotted lines between the terminals, show the circuits through when the handle is in the respective positions shown.

ON A PHENOMENON OF MOLECULAR RADIATION IN INCANDESCENT LAMPS.

BY J. A. FLEMING, B.A., D.SC.

Not long ago a curious phenomenon came under my notice in connection with the burning of Edison incandescent lamps, which presents sufficient interest to warrant me drawing the attention of physicists to it.



Edison Lamp used by Dr. Fleming.

As is well known, the carbon filament in the Edison lamp is of a horseshoe form. The two extremities of the loop are clamped into small copper clamps on the ends of the platinum wires, which are sealed through the glass. The ends of the carbon loop are electrotyped over with copper at the place where they are connected to the clamp, in order to make a good contact. If this precaution is omitted a loose contact may be formed, the result of which will be a generation of heat at that point. In the ordinary working the life history of a carbon filament is something as follows:—At some point or other the filament is probably thinner than at other places. At this place there will be a greater generation of heat and a higher temperature. Volatilisation of the carbon ensues, and the vapour condenses on the sides of the glass bulb, as far as I have observed, uniformly. If, however, the point of greatest resistance occurs on the copper clamp, then it is found that copper volatilises and deposits on the inside of the glass.

But what is most curious is that in this case an examination of the glass envelope shows that there is a narrow line along which no copper has been deposited. This is seen best by holding the lamp up before the light and slowly turning it round. In one particular position, easily found, it is best seen. Now, on examining carefully the position of the line of no deposit as compared with the carbon filament, it will be seen that it lies in the plane of the loop, and on the opposite side to that nearest to which the break of the loop has occurred. It is, in fact, *a shadow of the loop*, as shown in the illustration herewith.

The conclusion which must be arrived at, then, is that the copper molecules are shot off in straight lines, otherwise it is impossible that there should be this line of no deposit.

The most noticeable thing is that it occurs only when the deposition of copper takes place. I have never noticed it in an ordinary carbon deposit.

Hence there must be some essential difference between the vaporisation of the carbon and that of the copper. The carbon deposit resembles more the condensation of a vapour, and is uniformly distributed, but the copper deposit exhibits the character of a molecular radiation or shower taking place from a certain point.

The whole phenomenon calls at once to mind the beautiful researches of Mr. Crookes with vacuum tubes. Here, however, we are dealing not with an induction coil discharge, but with a comparatively low potential. I have never failed to see the effect in any lamp which has had a deposition of copper on its interior.

It is interesting to note how nearly the colour of transparent copper resembles that of transparent gold. The similarity of the surface colour of pure unoxidised copper and of gold is accompanied by a near resemblance in colour of the two metals in their films.

A HISTORY OF ELECTRIC TELEGRAPHY TO THE YEAR 1837.

BY J. J. FAHIE, MEMB. SOC. TEL. ENGS. AND ELECS.*

(CONTINUED FROM PAGE 41.)

Many of the authors, who describe the sympathetic needle (dial) telegraph, speak also of another form, which seems to have been especially believed in by the Rosicrusians and Magnetisers of the last two centuries. It was supposed that a sympathetic alphabet could be marked on the flesh, by means of which people could correspond with each other, and communicate all their ideas with the rapidity of volition, no matter how far asunder. From the arms, or hands, of two persons intending to employ this method of correspondence a piece of flesh was cut, and mutually transplanted while still warm and bleeding. The piece grew to the new arm, but still retained so close a sympathy with its native limb, that the latter was always sensible of any injury done to it. Upon these transplanted pieces of flesh were tattoed the letters of the alphabet, and whenever a communication was to be made it was only necessary to prick with a magnetic needle the letters upon the arm composing the message; for whatever letter the one pricked the same was instantly pained on the arm of the other.†

List of authors of the sixteenth, seventeenth and eighteenth centuries, who either describe the sympathetic needle and sympathetic flesh telegraphs, or make a passing allusion to one or both of them; chiefly compiled from Mr. Latimer Clark's list of books shown at the Paris Electrical Exhibition of 1881, and from

* The author reserves all rights of translation.

† Upon this delusion is founded Edmund About's curious novel, "Le Nez d'un Notaire," in which he relates the odd results of sympathy between the notary's nose and the arm of the man from whom the flesh was taken. But it is not in novels only, that we read of instances of the marvellous power of sympathy in these enlightened days; witness the story of "The Sympathetic Snail Telegraph" of Messrs. Biat and Benoit, which went the rounds of the newspapers forty years ago, and which the curious—we were going to say sympathetic—reader will find fully described in "Chambers's Edinburgh Journal" for February 15, 1851.

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the catalogues of the British Museum. As far as possible, only first editions quoted in full:—

1558 PORTA (GIAN B.). Magiae Naturalis, &c. Libri IIII. 8vo. (See page 90. Other editions: Antwerp 1561, 8vo.; Lugduni 1561, 16mo.; Venetia 1560, 8vo.; and 1665,12mo.). Neapoli, 1558.

1570 PARACELSUS (*i.e.*, Bombast Von Hohenheim). De Secretis naturae mysteriis, &c. 8vo. (Speaks only of sympathetic flesh, &c., telegraph. Numerous editions in British Museum.) Basileae, 1570.

1589 PORTA (GIAN B.). Magiae Naturalis, &c. Libri XX. Folio. (See preface to Book VII. for first clear mention of sympathetic needle telegraph. Other editions: Francofurti 1607, 8vo.; Napoli 1611, 4to.; Hanoviae 1619, 8vo.; Lugduni 1644 and 1651. 12mo.; London 1658, 4to.; and Amstelodami 1664, 12mo.) Neapoli, 1589.

1599 PANCIROLLUS (G.). Rerum Memorabilium, &c., 8vo. (See Book II. [Nova Reperta], chap. xi., Notes. This author refers to Scaliger [*Exotericarum exercitationem*, &c., exercit. 131], and Bodin. [*Methodus ad facilem Historiarum*, &c., chap. vii.], but they only speak of magnetic sympathy at great distances, without any reference to telegraphy. Other editions: two 8vo. Ambergae 1607 and 1612; four Francofurti 1622, 1629-31, 1646, and 1660; Lyon 1617; and London 1715.) Ambergae, 1599.

1600 DE SUNDE (J. H.) (*i.e.*, Daniel Schwenter). Steganologia and Steganographia, 8vo. (See page 127. Janus Hercules de Sunde is an assumed name. Hiller in the preface to his Mysterum Artis Steganographicæ 1682, says that it is a synonym for Daniel Schwenter Noribergense. And at page 287 he says, "Schwenteri is Est Hercules de Sunde." Other edition: Nürnberg 1650. 12mo.) Nürnberg, 1600.

1609 DE BOODT (ANSELMUS B.). Gemmarum et Lapidum Historia, &c. 4to. (See Book II. Other editions: Lugduni 1636, 8vo.; Lyon 1644, 8vo; and again Lugduni 1647, 8vo.) Hanoviae, 1609.

1610 ARGOLUS (ANDREAS). Epistola ad Davidem Fabricium Frisium. (He made what he calls a "Stenographic Compass," and held many agreeable conversations by its means with one of his friends). In Ephemeridae Patavii, 1610.

1610 ARLENSIS (PETRUS), of Scudalupis. Sympathia Septem Metallorum, &c. 8vo. (See chapter 2. This writer, a noted astrologer and alchemist, was the friend and fellow-citizen of Porta, to whom he seems to attribute the first conception of the sympathetic needle telegraph. His "Sympathia" was first published at Rome, but immediately suppressed in order that its grand secrets might not become known. It next appeared at Madrid in folio. The Paris ed. of 1610 was reissued at Hamburg in 1717.) Parisiis, 1610.

1617 STRADA (FAMIANUS). Prolusiones Academicae, &c., 8vo. (See Lib. II., Prol. VI. Other editions: Lugduni, 1617, and 1627. Sm 8vo.; Audomari, 1619, 12mo; Mediolani, 1626, 16mo.; Oxoniae, 1631, 8vo.; and again Oxoniae, 1745, 8vo.) Romae, 1617.

1624 VAN ETTEN (H.), (*i.e.*, Leurechon Jean). La Récréation Mathématique, &c., 8vo. (See page 94. This author is the first to give a drawing of the dial. H. Van Etten was a *nom-de-plume*. See *Notes and Queries* 1st series, Vol. XI., p. 516. Other editions: Paris, 1626; Lyon, 1627; and three London, 1633, 1653, and 1674. To the two latter is added a work of Oughtred, the editor, whose name is so conspicuous on the title page, that rapid cataloguers make him the author. Ozanam founded his "Recreations" on Van Etten; Montucla made a new book of Ozanam by large additions; and Hutton did the same by Montucla, so that Hutton's well-known work is at the end of a chain, of which Van Etten's is at the beginning. *Notes and Queries* 1st series, Vol. XI., p. 504.) Pont-à-Mousson, 1624.

1629 CABEUS (NICOLAS). Philosophia Magnetica, &c., folio. (See page 302.) Coloniae, 1629.

1630 HAKEWILL (GEORGE). An Apologie or Declaration of the Power and Providence of God, &c. Fol. (See page 285. This is second edition; a first appeared in [?] 1627, and a third in 1635. London and Oxford, 1630.

1631 KIRCHER (ATHANASIUS). Ars Magnesia, &c. 4to. (See pages 35 and 36.) Herbipoli, 1631.

1632 GALILEO (G.). Dialogus de Systemate Mundi, &c. 4to. (See page 88. Editions innumerable in British Museum catalogue. Fiorenza, 1632.

1636 SCHWENTER (DANIEL). Deliciae Physico-Mathematicae. (See page 346. This work is based on Van Etten's, *supra*. Two other 4to. editions appeared at Nürnberg 1651-3 and 1677). Nürnberg, 1636.

1638 MYDORGE (CLAUDE). Examen du livre des Récréations Mathématiques, &c. 12mo. (See Problem 74, pp. 140-44. This is a critically revised edition of Van Etten.) Paris, 1638.

1638 FLUDD (ROBERT). Philosophia Moysaica, &c. Folio. (See Sec. II., Lib. II., Memb. II., Cap. V., and Sec. II., Lib. III., *passim*. An edition in English appeared in London, 1659.) Goudae, 1638.

1641 KIRCHER (ATHANASIUS). Magnes, sive de Arte Magnetica. Sm. 4to. (See page 382. Other editions: Coloniae, 1643, 4to.; and Romae, 1654. Folio.) Romae, 1641.

1641 WILKINS (JOHN). Mercury, or the secret and swift messenger, showing how a man with privacy and speed may communicate his thoughts to a friend at any distance. 12mo. (See page 147. Another edition in 1694.) London, 1641.

1643 SERVIUS (PETRUS). Dissertatio de Unguento Armario, Sive De Naturae Artisque Miraculis. 12mo. (See para. 65, page 68. This work is printed in Rattray's "Theatrum," &c., *infra*.) Romae, 1643.

1646 BROWNE (SIR THOMAS). Pseudodoxia Epidemica, or Enquiries into very many received tenents, and commonly presumed truths. 4to. (See page 76. Numerous editions in the British Museum.) London, 1646.

1657 TURNER (ROBT.). Ars Notoria. The Notary Art of Solomon, showing the cabalistical key of magical operations, &c. 18mo. (See page 136.) London, 1657.

1657-9 SCHOTT (GASPAR). Magia Universalis Naturae et Artis, &c. 4 vols. 4to. (See Vol. IV., page 49. Copied from De Sunde and Kircher. Other edition: Bambergae, 1677. 4to.) Herbipoli, 1657-9.

1661 HENRION (DENIS) and MYDORGE (CLAUDE). Les Récréations Mathématiques, avec l'examen de ses problemes, &c. Premierement reveu par D. Henrion, depuis par M. Mydorge. Cinquieme et derniere ed. 12mo. (See Problem 74, pp. 158-61. This is only a revised edition of Mydorge's *Van Etten*, of 1638.) Paris, 1661.

1661 GLANVILL (J.). The Vanity of Dogmatising, and an Apology for Philosophy. 8vo. (See page 202.) London, 1661.

1662 WESTEN (WYNANT VAN). Het eerste Deel van de Mathematische Vermaeck, &c. 8vo. Three Parts. (See page 125, Part I. This is an enlarged Dutch edition of Van Etten's, *supra*.) Arnhem, 1662.

1662 RATTRAY (SYLVESTER). Theatrum Sympatheticum Auctum, exhibens Varios Authores de Pulvere Sympathetico, &c. 4to. (See page 546, see Petrus Servius, *supra*.) Norimbergae, 1662.

1663 HELVETIUS (J. F.). Theatridium Herculis Triumphantis, &c. 8vo. (See pages 11 and 15.) Haye, 1663.

1665 GLANVILL (JOSEPH). Scepsis Scientifica; or, Confest Ignorance the Way to Science, &c. 4to. (See page 150.) London, 1665

1665 SCHOTT (GASPAR). Schola Steganographica, &c. 4to. (See pages 258-264. Description from De Sunde's, *supra*, with an elaborate drawing of the dial. Copper-plate title-page bears date 1665, printed title-page dated 1680.) Norimbergae, 1665.

1676 HEIDEL (W. E.). Johannis Trithemii, &c., Steganographia que Hucusqu: a nemine intellecta, &c. 4to. (See page 358.) Moguntiae, 1676.

1679 MAXWELL (WILLIAM). De Medicina Magnetica, &c. Lib. III. 12mo. (See chaps. 11, 12, and 13.) Francofurti, 1679.

1684 DE LANIS (FRANCISCUS). Magisterium Naturae et Artis, Opus Physico-Mathematicum. 3 vols. (See Vol. III., page 412.) Brixiae, 1684-96.

1684 MARANA (G. P.) (or The Turkish Spy). L'Espion du Grand Seigneur, &c. 12mo. (See Vol. I., 13th letter, dated Paris, 1639. Six other editions in British Museum.) ? Paris, 1684, &c.

1689 BLAGRAVE (JOSEPH). Astrological Practice of Physick, &c. 12mo. (See page 112.) London, 1689.

1689 DE RENNEFORT (SOUCHU). L'Aiman Mystique. 12mo. Paris, 1689.

1696 DE VALLEMONT (PIERRE LE LORRAIN). La Physique Occulte, ou traite de la Baguette Divinatoire, &c. 12mo. (See page 32 of Appendix at end. Other editions: Paris and Amsterdam, 1693, 12mo., and Amsterdam, 1696, 12mo.) Paris, 1696.

1701-2 LE BRUN (PIERRE). Histoire Critique des Pratiques Superstitieuses, 2 Vols., 12mo. (See Vol. I., p. 294. Other editions: Amsterdam, 1733-36; and Paris, 1750-1.) Rouen, 1701-2.

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(TO BE CONTINUED.)

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THE ORIENTAL TELEPHONE COMPANY (LIMITED).

The third ordinary annual general meeting of this Company was held on Wednesday last, the 30th ult., at the City Terminus Hotel, Cannon-street, under the presidency of Colonel Gouraud.

The SECRETARY (Mr. W. G. Hall) having read the notice convening the meeting,

The CHAIRMAN said: Gentlemen, I am sure you will all be sorry to hear, as I am to inform you, that our chairman is unable to be here to-day. He is prevented from coming through death in his family—not his immediate family, I am happy to say, but under circumstances which make it impossible for him to be here, as this very hour is the hour of the funeral. Under the Articles of the Association of the Company, in the absence of the chairman it falls to the directors to select one of their number to take the chair, and my colleagues have asked me to do so. I was not aware that I should be asked until a few minutes ago, so it is rather short notice. However, with slight indulgence on your part, I hope to discharge the duty to your satisfaction. As one of the Board I have been actively concerned in the operations of the Company, and am tolerably informed as to its position, and I shall endeavour to anticipate such inquiries as occur to me that you are likely to desire to make, and to give you such information as I have in a general way. If I should, however, not cover every point, any questions that you may wish to ask I shall be very happy to answer as best I can.

The meeting agreed to take as read the minutes of the general meeting held on 8th February, 1883, and they were accordingly confirmed and signed by the chairman.

The CHAIRMAN (continuing): Gentlemen: Before moving the adoption of the report, which I presume you will also take as read, as it has been circulated among all the shareholders, I will call to your notice one or two points which first occur to me. While this is stated to be the third ordinary general meeting of the Company, I think it might, with great appropriateness, be said to be a statement of really the first year's business of the Company. Its operations, as you know, extend over a very wide sphere, include many countries, widely separated from each other, and all of them at a great distance from home. The early operations of the Company were very much embarrassed by many things, but I shall only mention two or three out of the number. We took over from the vendors a "going" business in certain places, and with it agents whom they had sent out. Almost without exception I am sorry to say those agents had to be replaced, and a very large amount of the work they did had also to be replaced, not representing a great deal of money, but a considerable loss of time. However, we have one after another been able to substitute those people whom we thought inefficient by others whom experience has since shown to be worthy of the choice we made. At the last meeting the chairman was able to say to you that the business of the Company in several places was fairly under way. He reported to you—and I remember the statement received your approval, as it was felt that it would—that there were then 409 exchange subscribers. Considering that we had hardly begun at all, that was a very fair number. Since then we have been able to increase our subscribers to the date of the report, which you are aware is the 31st December, to 1,098, showing an increase of 160 per cent. I may mention that since that date the increase has gone on steadily almost everywhere, so that to-day, taking the latest advices we have, which are contained in a letter received this morning, the number is considerably above 1,100—nearer 1,200. Well, I think you will take that as showing a very satisfactory increase in the number of subscribers; and in this connection I may say that the increase would have been very much greater, no doubt, if obstacles of a certain character, which are experienced almost universally in this kind of business, had not been met with, namely, the difficulties first of all in what we call way-leaves, or the running of our wires. Of course, we may have subscribers, but we cannot connect subscribers with the exchange if people who own houses between the residences or offices of the subscribers will not allow us to attach our wires to their roofs. That is the case in some instances. In other cases we depend on poles, and the views of municipal and governmental authorities in various parts of the world very greatly differ as to that matter. At one place, for example, in India, we were not allowed to run our wires on roofs, but were compelled to erect poles. They were very fastidious not only about the construction but the appearance of the poles. We had to construct them to a certain design, which was of an ornamental nature, involving a considerable outlay in India, but it has this advantage in the long run, that we are able to connect subscribers with much greater rapidity, and wires suspended on poles are, as a rule, more permanent. In other places we have not been able to run poles where we should have liked, and had to content ourselves with the fixing of wires to the housetops. As this business goes on, this difficulty may be taken to diminish, and we may hope for a proportionately more rapid increase in the facilities for connecting subscribers, and consequently a more rapid increase in the number of subscribers. In the next part of the report reference is made to the placing of £7,000 to the reserve fund to meet possible claims under guarantees arising out of the formation of the Bombay Telephone Company, Limited, to which company, you are aware, we sold our rights in Bombay, and under our agreement with that company we have guaranteed a certain rate of interest upon a certain amount of the shares, and out of the cash proceeds of the sale of the Company's business and rights there we have as a matter of precaution placed this £7,000 to reserve. The next paragraph contains a reference to the interim dividend and the source from which it was paid. I think I may here say a word about the subject of the interim dividend, and in the remarks I am going to make I wish to answer questions put in letters by several shareholders, all of which have been answered, apparently, satisfactorily. Some little objection has been made by one shareholder about the amount of this interim dividend—not that he objected to receiving the money when he received it, but that it was so small that it did not seem worth while to trouble the shareholders with it. The smallness of that dividend arises chiefly out of this fact, that the denomination of the shares is small—£1—and the amount paid upon the shares is small (10s.), consequently if a shareholder had very few shares his dividend is very small, and one very effectual remedy for the inconvenience would, of course, be to hold a larger number of shares. Still, if we had consulted our own convenience entirely, as it involved considerable labour upon the Board, I do not think we should have declared that dividend; but we have done so, and it is better to receive complaints from shareholders at receiving a small interim dividend than at not receiving any dividend at all. The next paragraph in the report refers to the Board. There are no alterations in the Board, it is stated, but that is hardly the case. There are no new directors to be appointed at the meeting, but there are some additions to the Board, as you will observe, since the last meeting, when it was pointed out by one of the shareholders, with some regret, that there appeared to be absent from the list of directors two or three well-known names, and questions were asked as to the reason of that. The inquiry referred to the names of Mr. Edison, Mr. Bell, and Mr. Hubbard. The Board then told the meeting that those gentlemen would be requested to re-join, and they were accordingly communicated with and gave their assent to re-join with the exception of Mr. Bell. Mr. Bell unfortunately found, according to a recent statement made to us by Mr. Hubbard, his father-in-law, that in his domestic generosity he had divided his shares among his family, and did not hold the qualification, but he will re-qualify himself out of deference to the wishes of the Board and re-join us again. The auditors of the Company retire under the Articles of Association, and offer themselves for re-election. With regard to Egypt, in the early days of the Company—or, rather, in the earlier days, because they are still early—at the first or the last meeting I remember the chairman indicated the policy of the Board as being one which should lead it to the formation of separate companies in the different countries we are interested in, not with a view to financing or getting rid of something that we did not want, but with a view to strengthening our position in the various places, strengthening it through interesting residents in those places in the shares as well as in the subscription list and the exchanges, and with a view by this means of overcoming the ordinary obstacles in the way of an extension of this kind of business. Besides the Bombay Company, particulars of which are given in full in the accounts, and which were further explained at the last meeting, which authorised the agreement to be carried out between this and that company, a company has since been formed for Egypt. In Egypt the progress of the Company has been very satisfactory indeed, and it continues to be so. Almost every mail brings us news of additions to the list of subscribers, and besides the business, not only at Cairo, but also at Alexandria (the only place where we are established which was entirely wiped out by the late war), it has been re-established, and the growth has been more than rapid in proportion to the time than it was on the first establishment prior to the late war. It will be a matter of satisfaction to you all to know that the service has been so satisfactory in Egypt, and has been so appreciated by the public and the Government, that they have recently extended our concession, which was limited to Cairo and Alexandria. It now includes Port Said, Ismailia, Zagazig, Suez, Mansourah, and Tantah, in all of which profitable business, it is believed, will be done; and we hope, before very long, to connect most if not all of those places, the one with the other, which will give a great stimulus to the whole business. An independent company has been formed to carry out the same policy as was employed before, and which was announced to you with a view to placing the shares in Egypt. No shares, however, have yet been placed there. Some time ago, when the Company was formed, in connection with which I should, perhaps, mention that a majority of the members of this Board are interested, it was thought desirable to have an independent chairman, and the directors were fortunate enough to secure for the position General Fraser, C.B., R.E., who for a long time was at the head of the Public Works Department in the Government of India, a gentleman of very excellent position, and no doubt a very good chairman he will make. Being deputy-chairman of that company, I may say that he has given a great deal of time and attention to it, and has a great belief in its future. At the time of the formation of the Company we began negotiations, or rather met overtures, to that end from some residents in Egypt, for the purchase of an interest in the shares of that Company. We are practically, perhaps, committed more than I wish we were to the promise of a sale of those shares, though we have not yet sold them. I think I am rightly expressing the feeling of the Board when I say that we shall not feel any particular regret if the negotiation falls through, as every day we see that the value of those shares is increasing. To-day the net receipts of the exchange itself show quite a respectable dividend on the shares which this Company holds in that company—the Telephone Company of Egypt. However, if the negotiations terminate in the sale of those shares we shall feel satisfied, as it is after all only carrying out the policy of the Company in interesting the people in various localities. In India—in Bombay, the agreement is completed with regard to the sale of this Company's interest there. We have received the money due to us, and we have received the shares of the business, which is now in the hands of a local company. The local Board, I am happy to say, consists of just the class of gentlemen you would all like to see there, and they are taking a great interest in it, and I have no doubt they are doing all they can. But I am bound to say that there the development is not quite equal to, at least, my expectations. It may go on more rapidly later on. They have not yet succeeded in tapping the native community. When they have done that, there and in the other countries in which we are concerned, we may look for a very large increase over present business. To do that they must, no doubt, vary their system of tariffs—possibly reduce them, and with that variation, even if it involves reduction, I feel certain that if once they get the natives to use their communication, there will scarcely be a limit to its extension. In one place, Egypt, the native element has already commenced to come in, and that is regarded as a very important circumstance. At Calcutta a local company has been formed, and there is a gradual increase in the business. There, as at Bombay, we have not yet secured any native subscribers. In time we shall, no doubt, do so. In Burmah the business is steadily increasing, though recent troubles in the rice trade have very materially retarded its progress. In Madras the progress is improving under improved construction. There was a case where the construction had to be practically replaced. We had to re-run practically all the wires. That is attributed to the climatic effects on the sort of wire used. We have obviated that, and endeavoured to meet the climate on its own ground. At Colombo the number of subscribers is small, but it shows a tendency to grow with lower rates. At that place the rates were too high, and that has been the case with many others. The communication is worth less to the subscriber when there are fifty than when there are 300 subscribers, and I am glad to say that in America, according to a statement I received this morning, they are adopting a policy of

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starting at low rates, say, with fifty subscribers, and in that case they charge fifty dollars a year. They charge five dollars extra a year with each additional fifty they get, and I think we should consider the same plan. In the Straits Settlements, the Singapore Exchange is a steady dividend yielding concern, which is steadily growing. I am told that Mr. Pell, our manager for Singapore, has just entered the room, and if I state anything that is incorrect I shall be glad if he will tell us. The business there is steadily increasing, and I congratulate Mr. Pell on the prompt way in which he has remitted us money. We wish that in every other place we had the same experience. We look to Singapore for a very material increase next year.

Mr. PELL: It is increasing daily.

The CHAIRMAN: That means a great deal. An increase of one a day would give us more than 300 a year. The local community are very much satisfied with the management, and we do everything we can to maintain its efficiency. We have independent assurance of that from members of the community there. In China the business has been disappointing. We have had many difficulties there. We were met, in the first place, by an existing establishment competing with us without any right to do so, but it is sometimes found that people will assume rights they have no claim to. We found that the case in China in more than one place, and we decided, as has been our practice everywhere, to assert our own rights, amicably at first, and then, if not successful, in some other way. In China, as the result of the course we took, we succeeded in bringing the people there to recognise our rights. In the result we have made a compromise with them, which, without troubling you with details, is entirely satisfactory. We have no competition or difficulty of that kind there now, but I am sorry to say that we have met there another difficulty which is entirely original, and differs from anything that we have experienced anywhere else. It appears that the Chinese were a great deal mystified by the extraordinary performances of the telephone at the beginning. In some cases they noticed, in certain conditions of the wind and the attachments to the roofs, that there was a certain musical sound, which I have heard sometimes myself, and which might be compared to the Æolian harp. But they thought it an evil spirit, and they have described it in their euphonious language, Fung Shui. That has retarded our development there, but I believe now that they are changing their minds about the influence of this mysterious spirit, and subscribers are increasing, we hope to overcome even Fung Shui. In the Hawaiian Islands we hope to receive a dividend during the current year. The business there, as you see from the figures in the report, is steadily increasing. That is one of the most remarkable cases of telephonic development I know anything about, and the accounts, when referred to, will offer me the opportunity to say something more specifically. In Mauritius we delayed beginning until recently, when representations were made to the Board from Port Louis, and we determined to open an exchange there on the assurance that it would meet with reasonable support at the outset—support that will cover our expenses, and show some prospect of a good return. The material and an electrician have already been despatched thither. The most significant remark I can make of a general character, after all, would be to tell you that the net receipts at the present time from what I may call really established business—the receipts from the payments by exchange subscribers themselves, without looking to anything from the sale of rights to companies, or the cash we may receive from such sales, give promise of a reasonable dividend in themselves upon our share capital, which is small as compared with the business we are doing and the extent of our operations. That, I think, you will all regard as satisfactory, and perhaps the most satisfactory feature of the business. In the accounts it might, perhaps, be better for me to abstain from any remarks, and answer any questions that may be asked. There are, however, one or two things which occur to me to remark upon. In the London expenses there are several items that struck me when I saw them come out in the books, although I was cognisant of the details that made them up throughout the year. Among them I would mention advertising, stationery, and printing. It seems to me that they were very large, and I am satisfied that they are larger than they will be next time. The printing item I looked into thoroughly, and I found it was due to getting a kind of information which we felt we must get so as to know every week what the position of the Company was. We have devised forms which we sent to all our agents, and when we were getting them printed, as the chief expense was the setting up, we thought we would get a larger number at once. With regard to the advertising we shall cut this down, as we do not find that it advances our business very much. As to the principal item, the directors' remuneration, I should call your attention to the fact that, while under the Articles of Association the directors are entitled to receive as their remuneration £2,500 a year, they have voluntarily amongst themselves decided for this year to take only £1,500. It is a pretty large Board, and, as my experience goes, an experience which I am happy to say is chiefly confined to telephone Boards, I think it very moderate remuneration considering the work done. We meet weekly—sometimes two or three times a week—and I have no doubt that our taking £1,500 instead of £2,500 will meet with your approval. I would say in this connection, speaking, perhaps, of myself, that I would not have you understand that our taking £1,500 this year should be regarded as meaning that we will not take any more in the future. My own impression is that when our dividends are materially increased you would be only too glad to pay us the remuneration prescribed by the Articles of Association, but till we pay a higher dividend I feel that we could not take more than we have done this year. Our interest in the Hawaiian Bell Telephone Company is in shares of the local company, and we have there an agent who looks after our affairs. We anticipated some little difficulty in that quarter, and we appointed this agent, a gentleman of very excellent position there, and together with a member of the legal profession who happens to be an old comrade of mine, they are looking after our interests. It was well for us that we had some one representing us, as we met an awkward suggestion there some time ago when a question was raised as to the legality of our holding shares in that company. In the accounts the nominal value of those shares is taken at something over £1,000, but the net receipts are so large that they show a very much higher value than the nominal value of those shares. In fact, although we have taken them in the accounts at their par value, we have been offered this year five times their amount, and as we thought they were worth more, we declined that offer. But we made a counter offer which was not accepted. However, immediately after that we were met with this pleasant intimation, that we were not entitled to any shares at all. We resisted this preposterous demand, and only the other day we got a telegram from our agent saying that we had won the case in court there. As to the expenses in London during construction, I would call your attention to the fact that the balance brought down as profit is reached only after charging to the year the whole of the London expenses. We thought that a proportion only of this item might be fairly charged this year, but after consultation with the auditors we thought that it would be better to be on the safe side and charge the whole in the working expenses of the year. I do not know that I need call attention to the fact, but we only paid a dividend upon £75,000 less than the total amount of the shares issued, the total amount being 297,000 shares. 75,000 of those shares we issued will not receive any dividend till the ordinary shareholders of the Company (practically preference shareholders) have received for five consecutive years dividends of 6 per cent. Mr. Griffiths, the auditor, calls my attention to the fact that the shares received in part payment of the Bombay sale have not been dealt with in the profit and loss account. Whatever may be realised ultimately for these shares, and no doubt it will be a substantial amount, will be entire profit. On the credit side of the balance-sheet there is a charge in reduction of preliminary expenses—an amount of £2,704. This is taken as a profit realised practically to the Company from the sale of the 20,000 ordinary shares which were authorised some little time ago, which were issued at a premium, and that premium represents this £2,700. At the time of this issue the shares were at a considerable premium above that, and it was an advantage to the shareholders to receive them at that price. They were all taken up by the shareholders, and the premium was dealt with in this way. All these stocks and stores mentioned in the balance-sheet are taken at their intrinsic value, and perhaps most of them have gone into actual construction since. Well, gentlemen, nothing further occurs to me voluntarily in the way of remark. I would have been more thorough and more satisfactory in my observations to you had I had a little notice that I was to take the chair. Before moving the adoption of the report, however, I should be happy to hear any questions that may be asked by any shareholders. Mr. Hall calls my attention to a matter that had escaped my mind, and which I should not omit to mention before sitting down, namely, that we are honoured to-day here, for the first time, at the Board with the presence of the most distinguished member of his profession in the world, Sir William Thomson. Before I resume my seat I should like to make this general remark, on the subject of the telephone industry. I presume I am not exaggerating when I say that there is no parallel in the whole history of applied science to the rapidity of the growth of the telephone industry as an industry throughout the world. I think its growth has been more rapid in the West than in the East, and relatively all the way round the world, unless you call the Hawaiian Islands in the East. I do not know exactly where they are. But certainly in America the development has been almost beyond conception. I received yesterday two or three figures, which I am sure it will be interesting to you to hear. The exchange subscribers in the United States number (this is not to date; no doubt the number is larger now) 100,000. The increase last year was 27,000. The mileage of the wires run last year was 30,000 miles—telephone wires—and the value of the telephone property in the United States, having no regard to foreign telephone companies at all, is estimated, at the market value of the shares, at 100,000,000 dollars, or £20,000,000 sterling. In England the development has been less rapid than in America, but there have been infinitely greater obstacles to contend against here of the character I have referred to, and also the difficulty that there was with the Government. In our own countries, I mean the countries where this Company is interested, I think, from the comparative slowness of the Eastern mind to open itself to such advantages, our progress has been very satisfactory indeed. We have one advantage that I have not yet mentioned as compared with England, an advantage which they have in America as compared with England, we have not to pay, with one exception—an English province—anything for the privilege of doing our business. That is the case in America, and the case in most of the places in which we offer it. We pay tribute to the Government for this privilege only in India, and they unfortunately take their example from the home Government, where we have, as you are aware, to pay. In Egypt and everywhere else we are regarded as public blessings, and we are not taxed for Government purposes. I shall be happy to answer any questions which any shareholder may have to put to me.

Mr. WRIGHT: I should like to ask how many shares there are in the new Bombay Company and our right there, and also how many in the Calcutta Company and our right there, and also for how many shares we have in each case given a guarantee under our agreement?

The CHAIRMAN: You would like to know the number of shares on which we guarantee.

Mr. WRIGHT: The number in that company.

Mr. A. F. PETTIFER: What is the amount you claim from the Indemnity Commission with respect to the losses of the Company at Alexandria? Then, again, I see in the balance-sheet £25,742 entered under the head of debtors. Will you be good enough to tell us if that is in your opinion a good asset?

The CHAIRMAN: In answer to the first question, the capital of the Bombay Company is 960,000 rupees, of which 840,000 are issued, and of the latter 480,000 claim our guarantee. Now, if the Bombay Company has the same development, that good luck that most other telephone companies have, we shall not be called on for anything under that guarantee. It would not surprise me, however, if during the first year we were called on for some portion of it, but my opinion is that with anything like reasonably good management on the part of the local Board there we shall on the average in the five years have nothing whatever to pay, and I hope that will prove to be the result. With regard to the other inquiries, I should prefer the honourable shareholder excusing me from answering his first question, for obvious reasons—the question what is the amount we have claimed for our injuries at Alexandria. It might prejudice the interests of the shareholders to do so, and I think you will see that. We have made a claim which we believe an honest one, and which if received will—I should hardly like to be reported as saying entirely compensate us—but we have claimed what we thought we might reasonably claim of the Government, and if we get that we shall be satisfied. As to the debtors, they have all paid since. That answers that question in the most satisfactory manner. We have got the cash. It was almost entirely owed by the Bombay Company.

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The SECRETARY: The capital of the Calcutta Company is 10 lacs of rupees, of which 880,000 rupees are issued. Our guarantee will extend to probably something like five lacs of rupees. We have not yet received the final accounts of that, as the transaction is not yet closed.

The Rev. F. C. FINCH: I should be very glad to know in what proportion the directors have attended the Board meetings. Another question I should like to know is the amount of shares they hold, and I should also be glad to know about the 20,000 shares which were hawked about in the auction mart.

A VOICE: 10,000 shares.

The CHAIRMAN: In answer to the last three questions I may say that the attendance book will show the number of attendances of the directors, and I think that question would be best answered to the satisfaction of the shareholder if I were to say that that book is at his service after the meeting. It is on the table. There are several gentlemen on the Board who, after having left the Company because they could not attend the meetings, living as they did out of the country, who are now on the Board again at the express wish of the shareholders. At this moment it may occur to you that there is a very small representation of the Board here. But Mr. Pender's absence I have accounted for, Sir Alexander Armstrong is here, Mr. Bigelow is ill, Mr. Cargill is abroad, Mr. Carnegy is here, Mr. Edison is in America, Mr. Hubbard lives in America, and Sir William Thomson is present. Mr. James Pender is in America, and Sir Julius Vogel is unavoidably absent to-day. He is only just returned from Australia, and, by the way, I may make some more reference to Australia which I omitted before. There the position of the Company is this, that we have not done all that we would care to do. There were some little matters in connection with which we succeeded in interesting Sir Julius Vogel when he was in Australia. Since his return he has laid before the Board a very full report, the substance of which is that we have rights there which can be enforced, if necessary, through the medium of the law, but we hope to avoid taking such measures. At the present moment there are agents in London who have full power of attorney to deal with us, and during the last two or three weeks some of us have spent two or three hours a day with those gentlemen over this question. As to the amount of the shares held by the Board, I do not suppose the shareholders would insist upon knowing the exact amount of the shares held by each director. I do not know whether it would not be out of his right to have the information if he wanted it. But I always prefer straining a point to give a shareholder something he has no right to if it will give him satisfaction. I may say, then, that the directors hold a very large amount of the share capital. I can say this further, and I speak with positive knowledge of the point, one is the largest shareholder in the Company. That, I think, will be all the information that the gentleman will require on that subject. The qualification is, perhaps, larger in this than in any other company.

Mr. FINCH: Will you tell us the qualification?

The CHAIRMAN: £1,000—1,000 shares. As to the hawking about of certain deferred shares, that was rather a sore point with myself. I do not know whose shares they were. You will fully understand that in a business of this character, the shares resulting from a transaction of this kind, numbering 75,000, would naturally be distributed among a great many people. There were several interests. The Bell and the Edison interests were separate in the beginning, and they together, in the first instance, received all these shares; but they had a great many partners, and they have been divided up. I can tell you that these shares were not my shares, or the shares of any of my immediate friends, so far as I am aware. We did consider whether we should take some notice of the circular, and were advised that we could not do so. The facts stated were, I believe, substantially correct, although it is, of course, a matter of surmise how soon the vendors' shares will receive a dividend. I did not form the impression, which the gentleman seems to have formed, that that circular was prejudicial to the interests of the Company.

Mr. FINCH: The shares went down very much.

The CHAIRMAN: I do not think in connection with that.

Mr. FINCH: It was at the same time, and they gave this circular as the reason for the fall on the Stock Exchange.

The CHAIRMAN: They give very strange reasons on the Stock Exchange.

Mr. FINCH: I had six or eight circulars.

The CHAIRMAN: I had as many. I should hope that the circular did no permanent injury to the Company. While on the subject of the shares, I should like to say this—and I say so on the authority of one who has had as large an experience as any one—whose experience dates, indeed, from the birth of the telephone. I speak of myself—that whatever may be the present price of shares in this Company, or whatever was the market price in the past—and you will remember that they have been at more than 100 per cent. premium at a time when a great many shares were not so well worth the price which these shares are selling at now—it is my deliberate opinion, and I think the facts which I have given you justify my opinion, that, regardless of the past or present market price of these shares—the market price being influenced by sometimes entirely extraneous causes—there has been no time when the shares of this Company were intrinsically worth anything like what they are worth to-day. That is my opinion. You may take it for what it is worth.

Mr. ST. JOHN ACKERS: As one of the largest shareholders, perhaps the meeting will pardon me if I ask a few questions and make a few remarks, not with any view of cavilling or finding fault with those gentlemen who have given their time to the interests of the Company, but rather, if I might say so, to strengthen the Company generally by having a few facts more thoroughly known. I believe that the more thoroughly our position is known the more thoroughly will the public appreciate it. A good many of the questions I had intended to ask have been asked and answered, most of them in a very satisfactory way. There are a few points as to the accounts that I should like to speak about. With regard to bills payable, and so on, I take it that the answer is similar to that which you gave to the gentleman who asked a question about the debtors. I take it that those were sums owing but not due when the accounts were made up to the 31st December.

The CHAIRMAN: That is so.

Mr. ST. JOHN ACKERS: That is satisfactory. As to the Alexandria indemnity I appreciate your answer, but I should like to ask whether our claim is one of those claims which have already been acknowledged? Certain claims, as I understand from the public papers, the indemnity commissioners already acknowledge.

The CHAIRMAN: A certain class of claims.

Mr. ST. JOHN ACKERS: I should like to know whether ours are included in that category. As to the question of our guarantee, I should like to ask whether there is any guarantee for other purposes over and above the guarantee under certain circumstances to pay a certain percentage on certain shares of the Bombay and Bengal companies. The guarantees here are put in a general form, and I should like to know whether there are any others.

A SHAREHOLDER: There are no guarantees as to Bengal.

The CHAIRMAN: You wish to know whether our claim for our losses at Alexandria is included in that class of claims which we understand will be allowed. I do not think we have information that will enable us to answer that question. We may say this, that they have taken our matter up and gone into the question, and probably by now have come to a conclusion on the merits of our claim. They have gone through the statement of our claim, and have had the amount of our losses examined into by experts. That is as far as I am able to answer the question, and I hope it will be satisfactory to you. There is this important addition that I may make—that our agent, who, by the way, is a most excellent and efficient man, and I do not know a more efficient man in the whole telephone world than our agent at Alexandria, advises us that he believes our claim will be met in full. He may be disappointed in that, and I do not give it as my opinion. As regards the Company's guarantee in connection with the Bombay and Bengal Company's shares, whether there is any further guarantee, if I understand your question, it is—does our guarantee involve us in the payment of anything beyond the deficiency in the net earnings of the Company upon a certain amount of shares?

Mr. ST. JOHN ACKERS: The question was if there was any other guarantee other than those in connection with those companies.

Mr. ROBINSON KENDAL: Your guarantee does not extend to Bengal, but only to the Bombay Company.

The CHAIRMAN: But Mr. Ackers's question is, having referred specifically to two guarantees, are there any others? At present in the accounts there is only one guarantee, but I have gone beyond that. I wanted to come down to the date of the report. Owing to the distance of our base we could not hold our meeting earlier. There are no other guarantees.

Mr. ACKERS: There is the question of these very great and very heavy expenses—the expenses in London. No one can look over these accounts and not notice that our expenses are at the present time out of all proportion to our business. I would earnestly ask the directors if there are not certain expenses which could not be materially reduced other than those mentioned. While you gave the expenses in London, you gave no idea of the expenses abroad. I take it—though I may be wrong—that there are other very considerable expenses abroad besides those which we have in the accounts for agents or managers, or whatever they be. It would, of course, be satisfactory to the shareholders to, at any rate, know that we are not paying large amounts to agents or managers in those countries where we are not either making satisfactory progress at present or where there is not immediate hope of satisfactory progress. As to the directors' remuneration—and here I touch on what is a most delicate point for a shareholder to speak on—we cannot, of course, expect gentlemen to undertake heavy work without adequate remuneration; but, at the same time, in your speech you alluded to the fact that you did not pledge yourselves to accept £1,500 for the current year's services of the directors. I would only say, in reply to that, that I earnestly hope, I will not say advise, the directors will be moderate with regard to what they accept till this Company has got on to a firmer basis—that is, more advanced than at the present time. I believe the basis is thoroughly sound and good, but we are in our infancy. Remarks are made outside. A gentleman spoke about an effect which had been produced on the Stock Exchange. I can only say that, directly this report got on the Stock Exchange, the first remarks I heard were as to the amount of the directors' remuneration in proportion to the profits. I, therefore, earnestly hope that this is a question that you will consider not only amicably, but in the forbearing spirit which has characterised the directors in the early days of the Company, which I hope may be continued perhaps even to a greater extent than has been already done. A good chairman deserves good remuneration, but I would put it to you whether there are not rather more English directors than are necessary for the business of the Company. I think it is quite certain that all the different interests ought to be represented on the Board, and, therefore, I think it is quite wise that Mr. Edison, Mr. Hubbard, and those gentlemen who had interests which we have absorbed, should be represented on the Board. But then I say the question I hope the directors will consider is whether there cannot be a saving as to other gentlemen who are on the Board. I do not propose to take up any further time with regard to many points I had desired information on, as I think that nearly all of them have been answered. I earnestly hope that we shall work together, both the shareholders and the directors, and that we may have a much more prosperous year this year. I hope in what I have said that I shall not be considered as antagonistic, but that it will be considered that I have only offered what I hope are legitimate remarks.

The CHAIRMAN: For my own part—and I only state what I believe every director would say—as to the last point of the hon. shareholder, there can be no objection to the matter or the manner—certainly not to the manner—in which he has presented his points. As regards the reduction of the London expenses, other than the directors' remuneration, I touched on one or two points which are having our careful attention. I do not believe there is very great room for reduction there, though everything counts in a case of this kind. Those expenses will have our attention, and I hope they will be dealt with in a manner which will meet with your approval. As regards the directors' remuneration, I am sure you will see that, when we have taken £1,000 less than we were entitled to, we have some ground for expecting a recognition of the fact from you, and that has been expressed by the last gentleman. Certainly the matter will have our very careful attention in the future. I said that our taking that £1,500 must not be considered as a precedent for our taking only £1,500 in future. I may say also that neither does it commit us to the taking of £1,500. I should say that if we do not improve even beyond the present very satisfactory position of the Company it will be open to us to consider whether we should not take less, and the reduction would not be much individually divided among the directors. I would say that I should be very much dissatisfied at taking less than I now get. I do not think I get enough, and I do not think my

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colleagues get enough. If we pay you a material, a more substantial dividend, as I think we shall, I believe that the shareholders would not begrudge us substantial remuneration. I think that the proceedings of the Company have shown that there is no difference whatever between the shareholders and the directors. With regard to the expenses abroad, they do not appear in detail in accounts of this kind. We have been under certain expenses abroad under two classes of service—one of agencies for our general business prior to the establishment of these local companies. It would have been more or less confusing to bring the details of those expenses into account. Those expenses have all had our very careful consideration, and the principal one we are under at present is one that comes to an end almost immediately—within the next two or three months. It is in connection with the services of a gentleman who has been our immediate negotiator in these cases. He has not had an unreasonable salary, but a good one. We gave him a percentage in accordance with certain results, and the result to him has been a fair remuneration, while the result to us, on the whole, has been satisfactory. The other expenses in connection with the formation of these companies we have purposely excluded from the accounts, for a reason which, when I explain, you will all appreciate and approve. We were obliged necessarily to have agents who do this kind of business so far from home—agents on whom we could depend, and who must be of the highest position in their communities, and while we have had to pay them, we have in no case paid them excessively. To publish the terms of our payments to them would, however, be like publishing the details of another man's business. I think, however, I may ask you to accept from me the assurance that we have paid no unreasonable commissions anywhere, and wherever we have secured the services of local gentlemen as directors we have invariably secured the services of such gentlemen as you would like to see in those positions.

Mr. A. F. Dewing: I am really sorry that I cannot agree with you about the Company being in such a very flourishing position. I do not consider that you have paid more than 2½ per cent. The other 2½ per cent. divisible is covered by the premium on the shares you issued, that we paid 12s. 6d. for, but which are now worth about 7-16 in the market. I do not know the view my brother shareholders take, but I do not at all hold that we are in the good position which you have represented us as being in.

Mr. Kendal: There is one point I should like to refer to. I agree somewhat with this gentleman, that this is not the best possible statement that could be submitted to the meeting. When you examine the figures you see that no great amount has been earned. We must also take account of this—that we have been working for eighteen months and not twelve months. The state we have to consider is not as to what was done last December, but as to what has been done to-day. We must see clearly, I think, that the position of this Company is to be regarded as at the present moment and not as on the 31st of December. As to the expenses abroad from the formation of the Company, are they included in the £48,000, or are they deducted from the cash? It appears to me it is not so much a question of the expenditure in London. If the directors take care in this £48,000 to see that it is reduced to a *minimum* they will have fairly earned their remuneration. I should like to ask, as a matter of inquiry, if the amount of those charges is included in the £48,000 for the formation of exchanges, or if the amount of the commissions is deducted from the amount received in cash or shares from the subsidiary companies, the net amount being then entered.

The Chairman: The answer I should have given you, Mr. Griffiths, who has audited the accounts on behalf of the shareholders, has noted down. Before showing the profit on the sale of exchanges all the costs of every nature are deducted.

Mr. Kendal: Deducted from the amount received?

The Chairman: Yes. With regard to the remarks of the gentleman who preceded Mr. Kendal, I would say that he has misunderstood the accounts. We have not taken the premium on those shares into the accounts. The comparison he has made is hardly fair. When those shares were taken by the shareholders—and no one took more than I did—at that premium, it was a decided advantage, and you could have sold the shares at that time at a considerable premium beyond that which was paid.

Mr. Pettifer: Will the directors take any fees in the Egyptian, China, or Japan Companies?

The Chairman: I presume they will, but I cannot say they have not taken any. There has been nothing to take. The capital, you observe, has not been placed.

Mr. Pettifer: What I want to understand is, when the capital has been placed will the directors take separate fees?

The Chairman: So long as the directors and the shareholders are only ourselves in this Company, the directors will not take such fees. I should think not. It has not been our practice to do so. I should scarcely think it would be an honourable thing to do, and it is not likely to be done. I now move: "That the accounts made up to 31st December, 1882, together with the directors' report, now submitted to the meeting, be approved and adopted, and that a final dividend for the year ending 31st December, 1882, of 2½ per cent., free of income tax, on the ordinary shares of the Company, be and is hereby declared."

Sir William Thomson, LL.D., F.R.S., M.I.C.E.: I have much pleasure in seconding the motion, and in doing so I would take the opportunity of congratulating the Company on the progress which has already been made. The work undertaken is, as you all know, one of very wide-spread ramifications, with centres of action over a very large area of the globe, and the amount of work involved in making arrangements to spread the operations of the Company so far and wide is something very serious. I have not myself taken part in the work of the Board, being only an *ex officio* member; but I am sure that my colleagues of the Board have worked exceedingly hard, although the profits hitherto have not been as large as we could wish. The business, however, seems to be in the most healthy condition, and it offers every prospect of a large increase, and an increase that may in every respect be looked forward to as giving a highly satisfactory future to the Company.

The Chairman put the motion in the usual manner, and it was carried. Continuing, he said: Gentlemen, the shareholders have to appoint an auditor. Messrs. Deloitte, Dever, Griffiths, and Co. were auditors last year, and their appointment expires under the Articles of Association. They, however, offer themselves for re-election, and I shall be glad to move that they be reappointed, or some shareholder might move it.

W. H. Newton, Esq.: I shall be happy to propose that the same auditors be appointed for next year at the same remuneration.

J. Sala, Esq., seconded the motion.

The Chairman put it, and it was carried.

Mr. Kendal: There is one question suggested to me that I should ask you. Do the directors contemplate—I would not say the probability, but the possibility, of making a call?

The Chairman: I think I ought to be able to answer that question very promptly in the negative. They cannot contemplate it, as it has not been mentioned among themselves, nor do I see any immediate occasion to consider it. That terminates the meeting.

A Shareholder: I beg to move a vote of thanks to the chairman for his conduct in the chair.

Mr. Kendal: I beg leave to second it.

The Chairman: On behalf of our absent chairman and my colleagues, both present and absent, I thank you very much for the patient manner in which you have heard all I had to say.

The meeting then separated.

SUBMARINE CABLES TRUST.

The twelfth ordinary annual meeting of the certificate holders in the Submarine Cables Trust was held at the offices, No. 66, Old Broad-street, on Tuesday last, under the presidency of John Pender, Esq., M.P.

The Secretary (Mr. Lewis Wells) read the notice convening the meeting and the minutes of the last meeting, which were confirmed by the present meeting. The report of the trustees was taken as read.

The Chairman: There is very little left for me to say beyond what is contained in this report. Our investments are not only in a good but in an improving position, more particularly the Eastern and Eastern Extension Companies. Their dividends have been increased, and that, of course, places our certificates in a better position. Last year, however, the Anglo-American went through a period of considerable competition and reduced rates, and our return from that source—which is a large investment in our trust—was less, and, consequently, gave us less money to invest in the purchase of our certificates. We consider that our certificates are now at a fair price, although, compared with the real value of the stocks, they are probably something like £10 below their actual intrinsic value. However, this value is more or less fluctuating. When an opportunity occurs, as we have money, we go on purchasing our certificates. We have very little in hand just now for that purpose, and therefore are not in a position to say we are buyers at the present time. With these remarks I beg to move, "That the report and accounts now submitted to the certificate holders be received and adopted."

The Marquis of Tweeddale seconded the resolution, which was at once unanimously passed.

On the motion of Mr. Aston, seconded by Mr. Cashman, the auditors, Messrs. John G. Griffiths and John Gane were re-elected.

A Shareholder: Are we likely to be free from further competition in regard to the Anglo-American Company, or can you give us any further information on this subject?

The Chairman: I can only give my own individual impression. After a considerable storm there is generally a calm, and we have had a great deal of storm and excitement about competition in the Atlantic. At one time there was a similar combination of the Press with Mr. Garrett, of the Baltimore and Ohio, but I think it was more talk than anything else. It always struck me that Mr. Bennett was not likely to do it on his own account, or that Mr. Garrett was likely to do it on his own account, as there was no response from the general public or their friends. It has assumed no form or shape, and there is, moreover, nothing to warrant another set of cables. We have now eight cables in the Atlantic. Those eight cables are capable of doing, I suppose, probably, three times the amount of work they are doing, because science has enabled us to duplex them, so that every cable, if in perfect working order, counts for two cables, or does as much work as two. Therefore, our cables are in excess of requirements at the present time. What they may be ten years hence I do not know, but meantime we are keeping so far ahead that the service is maintained in such a state that no one can complain, and I think there are really now chances of a lull. We have got as an ally, not as an enemy, perhaps the most bold and enterprising man, and as his cables are associated with ours there is not likely to be any opposition from that quarter. The Western Union is a very formidable body, and people will think twice before they tackle such a company. Then the Eastern Company is doing fairly well. I always think myself that telegraphs ought to pay better than they do. The Eastern Extension is also doing fairly well, and is likely to do better; and, looking at our investments as they stand in the list, I think they are of a very satisfactory nature. The public, too, are beginning to believe now in telegraph property as a permanent investment. Before, it was regarded as very speculative, but now we have pretty well, from our experience, made it a real property, which people believe in, and as they believe in it, knowing as we do the difficulty of investing money for our reserves at 4 per cent., we shall find that there will be a good demand for our certificates—a good security, with something like 6 per cent. I would, therefore, rather back the improvement than the retrograde.

Mr. Keenliside then proposed a vote of thanks to the chairman and the trustees for their excellent management.

Mr. T. H. Wells seconded the motion, which was carried unanimously.

The Chairman, in reply, said: This is not a big concern excepting in this—that your Board have, besides looking after the details of the trust—that is not so onerous—to watch the other companies from which we derive our revenue. We are engaged in those undertakings more or less, and, therefore, whatever we say you may regard as safe, and near the truth. We are always glad to have our services recognised by you, and we are somewhat disappointed if you go away without saying we have at least done the best we can for you.

The proceedings then terminated.

River Plate Telephone and Electric Light Company.—The report of this company states that the net revenue for the year was £4,475. The Preference shares are entitled to a 9 per cent. dividend.

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LONDON PLATINO-BRAZILIAN TELEGRAPH COMPANY (LIMITED).

The fifth ordinary general meeting of this Company was held at the offices, Old Broad-street, on Thursday, under the presidency of John Pender, Esq., M.P.

The SECRETARY (Mr. William Payton) having read the notice convening the meeting,

The CHAIRMAN stated that for the last three years they had paid a regular dividend of 2½ per cent., and the dividend they recommended on the present occasion would make the distribution for the past year at the same rate. They had had to draw to a slight extent on the amount carried forward on the last occasion in order to maintain this rate of dividend, which it was their desire to do. Since they had come to that decision they had received payment of a portion of the debt due to the Company by the Uruguayan Gouernment. There still remained £7,000 to be adjusted in connection with that debt. By keeping steadily at the Government they hoped to be repaid. He then referred to the sources from which the Company derived its revenue, and stated that the falling off in the cable receipts had been owing to the inequitable competition of the Brazilian Government land lines. He was hopeful that that Government would yield to the pressure which was being exerted with them in connection with this matter. He next alluded to their intention to endeavour to introduce certain economies, and stated that the Board had set the example in that direction by giving up £200 of their fees to the reserve fund. He concluded by moving the adoption of the report, and the payment of the dividend recommended.

Mr. HOLLOCOMBE seconded the motion, and in reply to questions,

The CHAIRMAN stated that they would be quite prepared to recommend the sale of the Company's property on fair terms. He spoke hopefully of the prospects of the undertaking. The motion was carried unanimously, and the retiring directors and auditors were re-elected.

A vote of thanks to the chairman and directors brought the meeting to a close.

CONSOLIDATED TELEPHONE CONSTRUCTION AND MAINTENANCE COMPANY (LIMITED).

The second ordinary meeting of this Company was held on Thursday, at the Cannon-street Hotel, under the presidency of Sir Julius Vogel, K.C.M.G.

The CHAIRMAN regretted that his task on the present occasion was much less agreeable than on the last occasion. No one had been more surprised than he at the unfortunate turn the affairs of the Company took in the past year. When he left this country for Manitoba last May he thought that their affairs were in as favourable a condition as they could desire, but on his return he found that a variety of adverse circumstances had happened. Acting under advice, they made a compromise for a large claim which had been made for the manufacture of telephones. Then the Post Office last June unexpectedly gave notice of the termination of the contract with the Company for 15,000 telephones. Again, one of the objects of the Company was to manufacture telephones for the United Company and its affiliated companies, but during the past year they had scarcely done anything for them. They had also had to employ a good deal of their means in respect to telephonic business in Austria. The contract of the Post Office had since in some measure been returned to them, and friendly and cordial relations had again been established with the United Company, for whom they would now manufacture telephones on the terms of the original contract. Important concessions had been obtained with regard to Austria, where there was every promise of a large business. A little difficulty which had arisen with the concessionaires would, it was hoped, be satisfactorily arranged. Their interest in the telephone in the River Plate was considerable, and it promised to be a good field for the enterprise. The directors still hoped to make the Company a success.

Mr. P. CARNEGY, C.I.E., seconded the motion, which was carried after some discussion.

FAURE ELECTRIC ACCUMULATOR COMPANY (LIMITED).

A meeting of the shareholders in this Company, convened by Mr. Harcourt Turner, was held at the City Terminus Hotel, on the 29th ult.

Mr. TURNER, having been voted to the chair, read a letter which he had received the previous night from the secretary of the Company, who, writing by instructions of the directors, amicably cautioned him to do nothing which should aid the enemies of M. Philippart or prejudice this Company and the French Company. A memoir was, the letter added, in hand for translation, showing that M. Philippart had been the victim of treacherous attempts. Continuing, the chairman said he thought he had better tell them what had passed between him and the secretary, and leave them to discuss what they considered best to be done under the circumstances. The first thing that attracted his attention was the payment of a dividend last January, because those of the shareholders who attended the meeting in November, when Sir Arthur Otway was in the chair, would remember that they were told that the Company was then doing no business. The old directors went out of office very soon after. The very first thing which the new directors did was to make a call of £1 a share, and also to declare a dividend of 3s. a share. On looking into the Articles of Association he found that the directors had very ample powers to determine themselves what was capital and what was income, and he therefore thought it was of no good to take any further steps in the matter. Affairs then went on until the arrest of M. Philippart. He then again wrote to the secretary, and reminded that gentleman that he had told him (the chairman) that the general meeting was to be held either in March or early in April, and that if not held by April he should take such steps as he should think fit to bring the affairs of the Company fully before the shareholders. To that letter he had received an answer, saying that the Board had fixed the 10th or the 17th of this month for holding the general meeting. Those dates had gone by, and it was quite clear to his mind that unless the directors had the "screw" put on them they would do nothing for the shareholders. At the beginning of this year M. Philippart was on the register of shareholders as the owner of over 20,000 shares, but on the register for April 11 the number of shares held by him had been reduced to 50; but at the same time there appeared the Société la Force et la Lumière for 30,000 odd shares. It seemed to him very strange, after the praise they heard from M. Philippart respecting the undertaking of the Company, that he should reduce the number of shares held by him to 50, which he must hold in order to retain his seat on the Board of the Company. In the letter he had referred to the secretary stated that the accounts of the Company were about to be audited, and that they would be duly submitted to each shareholder before the general meeting. It had occurred to him (the chairman) that if they could have the accounts that day it would be advantageous, and he had endeavoured to get them, knowing that the effort would be useless after he had issued his circular. He had had a reply from the secretary to his communication of the 14th. He read the letter, which stated that it had been thought advisable by the directors that the accounts should be made up to the 30th of April, and that the audit had not yet been completed. Owing to M. Philippart's detention, which the directors had reason to hope was only temporary, it had also been thought best to delay the general meeting, as the directors were assured that the interests of the shareholders would be better served if M. Philippart's attendance could be secured. Continuing, the chairman observed that the shareholders were aware that, by the Articles of Association, the accounts had to be made up to the 31st of December, and presented to the shareholders. Not a word was said in the circular of the secretary about extending the time, though he (the chairman) would be glad to see them made up to the 30th of April. It, however, seemed rather a strange way of doing business. That being the state of affairs, the question was, what could they hope to do in the way of business? As he had pointed out in his circular, the chairman of the Company was under arrest, and from all he (the chairman) could hear, he was likely to be in durance vile for some time. He had asked the shareholders to meet together to consider what was the best course to be adopted, and he should be happy to hear any suggestions to that end.

After some little discussion, Mr. L. A. Solomon moved, and Mr. W. D'Oyly seconded, a resolution to the effect that a committee of investigation should be appointed from among the shareholders to inquire into the present position of the Company, and to report theron to the shareholders with a view to decide as to what action should be taken thereon, but that no active steps be taken by the committee until after June 26, the day appointed by the directors for their annual meeting.

The resolution was passed, and subsequently Messrs. Ponsonby, Harcourt Turner, L. A. Solomon, and Mr. D'Oyly were appointed members of the committee, and it was decided that Sir Charles Clifford should be also asked to join it.

A vote of thanks to the chairman for convening the meeting, brought the proceedings to a close.

ELECTRIC LIGHTING OF LEEDS.

Supplemental particulars relating to the proposed lighting by electricity o portions of the municipal buildings at Leeds for the Corporation.

The attention of companies and persons who may intend submitting tenders for lighting by electricity the places mentioned in the particulars issued by the Electric Lighting Committee of the Corporation of Leeds, and dated the 21st inst. (*see The Electrician* for May 26, p. 43), is directed to the following supplemental particulars having reference to the proposed lighting. At a meeting of the committee, held at the Town Hall, Leeds, this day, it was reported that in response to the invitation of the committee for suggestions as to probable improvements generally in the proposed scheme of lighting, several communications had been received from companies and persons desirous of tendering, suggesting for the consideration of the committee the desirability of the clause in the particulars issued on the 21st inst., relating to the employment of a particular type of dynamo-machine being modified, when after the subject had been considered it was resolved—"That, having regard to the suggestions now made, the committee conclude to modify the clause so as to allow companies and persons tendering to suggest for use such types of dynamo machines as they may consider best adapted for employment in connection with the particular system of lighting comprised in the tender."

It was also resolved that the following further alteration be made in the particulars, viz.:—That the clause on page 10 reading: "All wires must be carried to the various groups of lamps by means of wood mouldings, to harmonise with the walls and mouldings of the ceilings, &c., so as to cover up and preserve the wires," be cancelled, and that in lieu thereof the following clause be substituted, viz.:—"The committee, will, at their own cost, open in the walls and other places such receptacles as may be necessary to receive interior wires, and that after the contractor has placed the wires in position, the committee will cover up and make good such receptacles, and will also cover with wood mouldings such wires as may be exposed, or which may require protection."

Also, that the clause on page 10, reading:—"Incandescent lamps.—'Swan' or other approved lamps of not less than 20 candle-power must be used. The committee will, however, reserve to themselves the right to accept or require to have employed any other description of incandescent lamp of the same candle-power in connection with the proposed installation" be cancelled, and that in lieu thereof the following clause be substituted, viz.:—

Incandescent lamps.—"'Swan' or other approved lamps of not less than 20 candle-power must be used."

By order of the Electric Lighting Committee.

(Signed) GEORGE W. MORRISON,
Town Hall, Leeds, 29th May, 1883. Town Clerk.

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COMPANIES' SHARE LIST.

TELEGRAPHS.

Companies.	Closing Prices May 30.		Business Done Week Ending May 30. Highest.	Lowest.
Anglo American	50,	51	50½	50⅜
Do. Preferred	82,	83	82½	81½
Do. Deferred	19½,	20½	20⅜	20
Brazil Submarine	11¾,	12	12⅛	11 13-16
Cuba	10,	10½	—	—
Do. Preference	17,	18	—	—
Direct Spanish	5½,	6½	6	6
Do. Preference	16,	16½	—	—
Direct United States Cable	12½,	12¾	13	12¾
Eastern Telegraph	10¾,	11	11	10 13-16
Do. 6 per Cent. Preference	13,	13½	—	—
Do. 5 per Cent. Debentures, 1899	104,	107	104½	104½
Eastern Extension	12,	12½	12 3-16	12
German Union	9¾,	10¼	9¾	9¾
Globe Telegraph and Trust Company	6¾,	7⅛	7½	7
Do. Preference	12¾,	13	13	12¾
Great Northern	12¾,	13	13	12¾
Indo-European	31½,	32½	—	—
Mediterranean Extension	1½,	2	—	—
Do. Preference	6,	7	—	—
Reuter's	9½,	10	—	—
Submarine	247,	252	—	—
West India and Panama	1⅛,	1⅜	—	—
Do. 1st Preference	6½,	7	—	—
Western Brazilian	6½,	6¾	6⅝	6⅝
West. Union 7 per Cent. 1st Mortgage	122,	124	—	—
Do. 6 per Cent. Sterling Bonds	103,	106	—	—

TELEPHONES.

Consol. Telephone and Maintenance	½,	¾	11-16	9-16
Oriental	⅜,	⅝	½	7-16
United Telephone	9½,	9¾	9½	9½

ELECTRIC LIGHT.

Anglo-American Brush Lgt. (£7 paid)	4,	4½	4⅝	3⅝
Do. (fully paid)	7,	8	8	6 13-16
Hammond Light	2½,	3	2¾	2¾
Pilsen, Joel, and General Electric	⅛,	⅜	—	—
Swan	1⅝,	1⅞	1 11-16	1½
Maxim-Weston	⅛,	⅜	¼	¼

Numbers of "The Electrician" out of Print.—The following numbers of *The Electrician* are out of print, and cannot be supplied at the office, viz.:—Vol. 1, Nos. 3, 9, 19; Vol. 7, Nos. 8, 10, 12 to 18, 20, 21, 24 to 26; Vol. 8, 1, 3, 6 to 12, 15 to 26; Vol. 9, Nos. 2, 4, 24, 25; Vol. 10, No. 13.

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BY

E. MASCART,

Professor in the College de France, and Director of the Central Meteorological Bureau;

and

J. JOUBERT,

Professor in the College Rollin.

Translated by E. ATKINSON, Ph.D., F.C.S.,

Professor of Experimental Science in the Staff College.

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NOTES.

SOUTH AMERICA.—The cable between St. Elena and Payta is repaired.

ARABIA.—Telegraphic communication is restored with Jeddah and other places in Hedjaz, Arabia.

NEW CABLE.—The French Cabinet have been discussing the question of laying down a cable to connect Saigon and Tonquin.

TELEGRAPH CONSTRUCTION AND MAINTENANCE COMPANY.—This Company's Bill received the Royal Assent by commission on the 31st ult.

ELECTRIC RAILWAY BRAKE.—*L'Electricité* learns that M. Achard's electric brake has been definitely adopted by the directors of the State railways.

LONDON ELECTRIC WIRE COMPANY.—This company has removed from Wenlock-buildings, Ironmonger-row, to Anchor Works, Playhouse-yard, Golden-lane, E.C.

THE BRITISH ASSOCIATION.—Professor Lord Rayleigh has been nominated by the Council of the British Association as president for the meeting at Montreal in 1884.

LEEDS GAS.—It may be interesting to electricians to know that the official report on Leeds gas for the past month gives its average illuminating power as 17·18 candles.

M. PHILIPPART.—A telegram from Brussels, dated June 6, states that M. Philippart was provisionally set free on that date, on giving bail to the amount of 15,000fr.

TENDERS WANTED FOR ELECTRIC LIGHTING.—Tenders are being invited for lighting the Royal Aquarium, Westminster, and St. James's Hall, Burnley, by means of electric lights.

TELEGRAPHIC EXTENSION IN CANADA.—The telegraph line between Qu'appelle and Touchwood Hills has been successfully completed, and the through line to Humboldt is expected to be at work shortly.

WEST INDIA AND PANAMA TELEGRAPH COMPANY.—The estimated traffic receipts of this company for the half-month ended May 31 are £3,028, as compared with £3,261 in the corresponding period of 1882.

THE TELEPHONE IN CANADA.—According to recent news from the Dominion, arrangements are being made for telephonic communication between Kingston and Toronto, Hamilton and Western Points.

ELECTRIC LIGHTING IN BAVARIA.—The King of Bavaria's new palace at Neuschwanenstein is lighted internally by means of Edison lamps, whilst Jablochkoff lights are employed for external purposes.

THE BRUSH SYSTEM IN BRAZIL.—The Brazil Government have confirmed the patent held by the Brush Electric Light Company. The latter are establishing forty of their lamps in the streets of Campos.

DIVIDEND.—The directors of the Brazilian Submarine Telegraph Company have declared an interim dividend of 3s. per share, or 6 per cent. per annum, for the quarter ended 31st March last, and payable on the 25th inst.

ELECTRIC LIGHT ON A CHINESE IRONCLAD.—The Chinese ironclad, "Ting-Ynen," which has recently been built in a German dockyard at Stettin, is lighted by means of 240 Edison lamps. Ting-Ynen means, we believe, eternal peace.

THE TELEPHONE IN COLLIERIES.—The Société John Cockerill, of Seraing, near Liege, Belgium, have recently introduced the telephone into one of their collieries. The instruments are said to work well at a depth of 350 metres (about 383 yards).

GREAT NORTHERN TELEGRAPH COMPANY.—The traffic receipts of this company for May, 1883, were £22,600. For the period 1st January to 31st May, 1883, they amounted to £99,520, whilst for the corresponding months of 1882 they were £94,150, and for the same period of 1881, £93,172.

ELECTRIC LIGHTS FOR CARRIAGES.—The Vienna correspondent of the *Daily News* telegraphed from that city on Sunday night as follows:—"Last night Baron Rothschild's carriage was lighted by electricity. The accumulators were placed under the coachman's seat. The electric lights were inside the usual lamps."

MORE WIRES.—To meet the expected increase of traffic on the introduction of sixpenny rates the General Post Office are putting up two new wires between London and Glasgow, one between Bristol and Glasgow, and one between Newcastle-on-Tyne and Glasgow. Others are to be put up in course of time as funds allow.

A NEW STEAMER.—The "Gabo," a new steamer, built by Messrs. J. Key and Sons, at Abden, Kinghorn, Scotland, for Messrs. W. Howard, Smith, and Sons, of Melbourne and Sydney, was launched this week. She is 280 feet long, and has a gross tonnage of 2,042 tons. It is stated that she will be lighted on the incandescent system.

CUBA SUBMARINE TELEGRAPH COMPANY.—The number of messages passing over the lines of this company during the month of May was 3,848, estimated to produce £3,300, against 3,408 messages, producing £3,544 in the corresponding month of last year. The traffic receipts for the month of February, estimated at £3,900, realised £4,036.

APPOINTMENTS.—Lieutenant-Colonel Alexander Lipoianu has been appointed Director-General of Posts and Telegraphs in Roumania.—We understand that Mr. O. Loring, for some time one of the electricians of the Anglo-American Brush Light Corporation, has been appointed manager and chief electrician to the Northern Electric Light, Power, and Appliances Company (Limited).

WEST COAST OF AMERICA TELEGRAPH COMPANY.—This company give notice that telegraphic communication with Valparaiso, Mollendo, Arica, Iquique, Antofagasta, Santiago de Chili, Buenos Ayres, and all telegraph stations in Peru, Chili, and the Argentine Republic is now re-established *viâ* Galveston. The tariff per word from Great Britain to Valparaiso is 14s. 8d., and to Buenos Ayres 13s.

ELECTRIC LIGHTING IN AN ASYLUM.—We understand that the Committee of the Gloucester County Asylum have decided to light a portion of their new buildings with electric light, and have entrusted the contract to Messrs. Woodhouse and Rawson, of 11, Queen Victoria-street, London. Otto gas engines, with Dowson's patent gas, Sellon-Volckmar batteries, and Woodhouse and Rawson incandescent lamps are to be used.

A HAND-DRIVEN DYNAMO.—Mr. W. E. Fein describes in *Carl's Repertorium* a hand-driven dynamo on the Gramme system, which is capable of producing in a voltameter from 180 to 200 cubic centimetres of gas, and of maintaining at a glowing heat a platinum wire half a millimeter in diameter, and half a metre long. At 1,200 turns per minute the E.M.F. is equal to from eight to ten Bunsen elements.—*Wiedemann's Beiblätter*, 1883, No. 1, p 55.

TELEGRAPH STORES WANTED.—The North-Eastern Railway Company are inviting tenders for the supply of telegraph

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apparatus and telegraph wire and line stores for the six months ending 31st December next. Forms of tender may be obtained on application to Mr. Graves, Telegraph Department, York, and tenders must be sent in to the Secretary of the Company, at York, sealed and marked "Tender for Telegraph Stores," not later than noon on the 22nd instant.

Messrs. Johnson and Phillips.—We are informed that Mr. Bennett Pell, late of the Eastern Extension Telegraph Company, has become associated with the firm of Messrs. Johnson and Phillips, telegraph engineers and electricians. We think that this well-known firm are fortunate in securing the co-operation of a gentleman of such activity and wide telegraph experience, and Mr. Pell will, we are sure, find ample scope for his energies in his new sphere of labour.

Notes from Ceylon.—The *Colonies and India* says :—"Very severe lightning storms have occurred in Colombo, the surveyor-general's office being struck and the occupants much alarmed. It was believed that this was due mainly to defective insulation of the newly-erected telephone wires. The subscription to the telephonic exchange in Colombo is to be reduced from the former almost prohibitory rate of 300rs. to half that sum, and arrangements have been made with the Government Telegraph Department for concurrent working."

Electric Exhibition at Vienna.—Four hundred exhibitors have given notice to the Committee of the International Electrical Exhibition to be held here, says the Vienna correspondent of *The Times*—216 from Austria, 70 from Germany, and 19 each from England and Italy. There are already 36 notices from France. Ten Austrian insurance companies jointly undertake the insurance of the objects exposed. The French, Belgian, and German railway companies have consented to a reduction of the tariffs for visitors to the exhibition.

Steamship "Cotopaxi."—It will be remembered that a fire occurred on board this vessel a short time since, doing considerable damage, and, amongst other things, destroying the electric light wires with which she was fitted. The dynamos (Bürgin) were saved at the time of the fire, and have been replaced. The ship has also been re-wired throughout by Messrs. R. E. Crompton and Co. She belongs to the Orient line of steamers, and was lighted by Swan incandescent lamps for the first time some fifteen months ago, Messrs. Crompton and Co. carrying out the work.

The Postal and Telegraph Services.—The annual conference in connection with the United Kingdom Postal and Telegraph Service Benevolent Society was held at Bristol on Monday last, when upwards of fifty delegates attended from forty districts in various parts of the kingdom. The report showed that no less than twenty-six districts had been added in they ear,and 835 new members enrolled. The widows and relatives of deceased members had received £6,000 in the past year, bringing the total payment to £20,880 since the establishment of the society. Next year's meeting will be held at Edinburgh.

Steamship Lighting.—The ss. "Clan MacArthur," which has been built for Messrs. Cayzer, Irvine, and Co's Clan Line, by Messrs. Scott and Co., of Greenock, started from the Clyde on Saturday, the 2nd instant, for a preliminary cruise with a large party on board. The vessel has been lit throughout with incandescent lamps by the Glasgow branch of the Edison Electric Light Company. We understand that the owners have been so pleased with the complete success of the lighting that they have placed the lighting of another steamer, the "Clan MacIntosh," with the Edison Company, without inviting tenders from other firms.

The Telephone in Brazil.—By an imperial decree of the 21st April the Government confirmed the patents granted by the United States to Alexander Graham Bell for his telephone. A company has been formed in Rio de Janeiro, under the title of the Companhia Nacional de Electricidade, with Mr. C. P. Mackie as president, and has purchased the sole right to use the Bell and other patents in Brazil from the Tropical American Telephone Company. The Companhia Nacional have granted a license for Rio de Janeiro and Nitheroy to the Companhia de Telegraphos Urbanos, of which Mr. W. J. Donshea is superintendent and Mr. Victor Dias manager.

Electric Lighting at Cardiff.—The Brush lamps that have for some time past been used to light St. Mary-street, Cardiff, have been replaced by Crompton arc lamps, the current for which is supplied by a Bürgin dynamo. The front of the theatre and the Washington Hotel are also lighted by Crompton lamps. The work has been carried out by Mr. Lascelles Carr, of the *Western Mail*, who introduced the electric light into his own offices some time ago. We believe that a considerable amount of electric lighting work is on the point of being commenced in this locality by Mr. Carr, in conjunction with the Swan United Electric Light Company.

Huddersfield Technical Schools Exhibition.—We understand that the order for the lighting up of this exhibition has been secured by Messrs. Kingsland and Smith, of Leeds, agents and district managers for the Yorkshire Brush Company, and Messrs. Ferranti, Thompson, and Ince (Limited). This exhibition, which will be similar to the one held at Bradford last year, is to be opened the first week in July, and is expected to remain open till about November A 40-light Brush machine will be used for lighting up the the weaving and other sheds by Brush arc lights, while a 300 light Ferranti dynamo will be used for operating incandescent lights in the rest of the building.

Electric Lighting in the West End.—Lord Randolph Churchill's house, No. 2, Connaught-place, W., has been lighted by Swan lamps. A 3 horse-power Otto gas engine has been fixed in the cellar under the porch, and drives a compound Bürgin machine, which charges 60 one horse Faure-Sellon-Volckmar accumulators in the daytime. The current is taken from the accumulators at night as required. Should it be necessary, the engine and dynamo can be driven at night, and the current passed through the accumulators, which then act as regulators. About 80 Swan lamps are used at present. The work has been satisfactorily carried out by Messrs. R. E. Crompton and Co., of Mansion House-buildings.

Electric Lighting in Switzerland.—The project of lighting the canton of Vaud, in Switzerland, by means of electricity is engaging the attention of several engineers in Lausanne at the present time, says *L'Electricité*. A central station intended to supply the motive power will be established at Vallorbes, near the source of the Orbe, and by this means the waters of lakes Joux and Brevets will be utilised. Water will be brought from near the Bonport Mills to Vallorbes by means of a tunnel 800 metres long. The quantity of water that will thus be placed at the disposal of the engineers will be about 2,500 litres per minute (about 100 gallons), and will be capable of giving to the turbines of the station a motive power equal to 500 horses (the French h.-p. is smaller than the English), sufficient to light 2,500 electric lamps.

Tampering with Telegraph Boys.—At the Stockton Police Court, a few days ago, Thomas Higgins, bricklayer,

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was brought up on a charge of soliciting and endeavouring to procure certain telegraphic messages from W. H. Laing and J. E. Lumley. Mr. C. J. Archer appeared on behalf of the postal authorities, and showed that the prisoner met the lads in the streets, and endeavoured to effect an arrangement with them as to what had won the big race—meaning the Derby—and if they would tell him he would give them half-a-crown; the object being to obtain the winner of the race, and then bet on it before the result was generally known. The boys, on returning to the office, told Mr. Brown, the postmaster, and hence the prosecution. Other evidence confirmatory of the above having been given, prisoner was committed for trial, bail being accepted.

Time Signalling.—In the annual report of Mr. W. H. M. Christie, astronomer royal, he says:—"There has been no case of failure in the automatic drop of the Greenwich timeball. On three days the ball was not raised on account of the violence of the wind. The Deal ball has been dropped automatically at 1 p.m. on every day throughout the year, with the exception of five days on which there was a failure in the telegraphic connection, of one day when the ball was accidentally dropped 4sec. too soon by telegraph signals, and of 14 days when the current was weak and the trigger was released by the attendant. On 12 days the ball was not raised because of the violence of the wind. The Westminster clock has maintained its high character, its errors having been under 1sec. on 66 per cent. of the days of observation, between 1sec. and 2sec. on 25 per cent., between 2sec. and 3sec. on 6 per cent., and between 3sec. and 4sec. on 3 per cent. The error has never exceeded 4sec."

Electric Lighting on a Yacht.—The "Empress," steam yacht, which we mentioned some time ago as about to be lighted by incandescent lamps, is now lying in the Thames, off Greenhithe. She has been fitted up with 32 Swan incandescent lamps, which are fed by Faure-Sellon-Volckmar accumulators supplied by the Electrical Power Storage Company. The accumulators are charged by means of a shunt wound Bürgin dynamo, driven by a three cylinder Brotherhood engine fitted up near the yacht's engine room. Steam is supplied to this engine by a separate boiler made by Messrs. Cochrane, so that steam can be got up when lying in harbour, or when the yacht is sailing and fires damped down under her other boilers. The fittings have been supplied by Messrs. Faraday and Co., of Berners-street, Oxford-street, W., and are adapted for candles as well as electric lamps. The installation has been carried out by Messrs. R. E. Crompton and Co. The yacht was built by Earle's Shipbuilding Company, of Hull, for her owner, Sir A. Walker.

Magnetic Observations at Greenwich.—In his annual report, which has just been issued, Mr. W. H. M. Christie, astronomer royal at Greenwich Observatory, makes the following remarks with reference to the year's magnetic observations:—"A great improvement," he says, "has been made in the photographic registrations by the substitution in June of Morgan and Kidd's argentine-gelatino-bromide paper, with ferrous oxalate development, for the old process. The large temparature correction of the vertical force magnetic has been reduced to less than one-fourth of its former amount by some alterations which were carried out by Mr. Simms last autumn. There has been considerable magnetic activity during the year, the month of November (which was characterised by the appearance of a very large sun-spot) being particularly disturbed with remarkable magnetic storms on November 17, 19, and 20, and many interesting cases of lesser disturbance. The magnetic disturbances on October 2 and November 17 were accompanied by brilliant auroras."

Electric Lighting in Malta.—On Tuesday, May 29th, the Chevalier E. Rosenbusch, C.E., on behalf of the Eastern Electric Light and Power Company, gave an exhibition of incandescent lighting at his residence in Strada Mercanti, Valletta. "A large number of visitors were present, amongst whom we noticed," says the *Malta Standard*, "His Excellency the Governor, Captain Borton, General and Lady and the Misses Feilding, Colonel and Lady Crichton, Honourable Captain Carr, Sir Adrian and Lady Dingli, Baron and Baroness Testaferrata Abela, and others. As soon as His Excellency arrived, the La Valette band, which was in attendance, struck up "God Save the Queen," and the street was brilliantly illuminated with the electric light. The exhibit went off with great success. The lights displayed consisted of side lights, chandeliers and table lamps of variegated colours, and gave every satisfaction to those present, who heartily congratulated Chevalier Rosenbusch and Mr. William Robinson, the electrical engineer, who lucidly explained the system to the company."

Electric Lighting for Dundee.—At a recent meeting of the Dundee Gas Commission it was announced that the following terms had been arranged with the Brush Company with reference to their provisional order:—That the company should appropriate £20,000 of capital for providing a station in Dundee forthwith, and deposit £3,000 in security for the performance of the obligation. That the Police Commissioners should be allowed to open streets at the expense of the Brush Company for the purposes of new works, and that electric lighting could be demanded by the Police Commissioners on such terms as might be settled by an arbiter, failing agreement with the company; further, that one or more streets might be lighted with one or more lamps in any street without any general obligation being undertaken. The area of supply was also fixed in terms of the Gas Commissioners' original requirements, and the clauses adjusted providing that if nothing was done within four years the order should lapse, subject to the Board of Trade imposing such terms upon the Brush Company for their breach of order as might be deemed right.

Electric Light on Ships.—The Pacific Steam Navigation Company's ss. "Liguria" has just been fitted with fifty Swan lamps by Messrs. R. E. Crompton and Co. The current is supplied by a Bürgin dynamo machine, driven by an eight horse-power vertical engine supplied by Messrs. Marshall and Co., of Gainsborough. This engine gives more power than is at present required, but has been supplied with the idea of providing power for double the number of lamps at present in use. The latter are coupled up two in series, and are fitted in the ordinary candle lockers, so as to throw light into two cabins and the passage at the same time. There are sixteen lamps in the saloon, two to each table, instead of the five candles hitherto used; they have medium opal globes and plated fittings. The machine and engine are fitted up in the ship's engine room, and are looked after by the engineer on watch. One lamp lights the smoking room on deck. The work was carried out to the satisfaction of Mr. Shoolbred, consulting electrical engineer to the Pacific Steam Navigation Company, by Messrs. R. E. Crompton and Co., of Mansion House Buildings, Mr. Lockhart having charge of the installation.

Secondary Batteries.—Messrs. R. Tatham and A. Hollings, of Rochdale and Salford, respectively, have taken out a patent for a new method of constructing plates for secondary batteries. Their process is as follows:—"Paper pulp

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prepared from unsized paper, cotton, linen rags, or other vegetable fibre is mixed when moist with twelve times its volume of peroxide of lead for the positive element or anode, and with a similar quantity by volume of sub-oxide of lead for the negative element or cathode, so that the mixture or compound contains about 93 per cent. by volume of the metallic or active agent. The proportions by volume of the materials above mentioned are found to answer well in practice, and the use for the anodes and cathodes of metallic salts of two degrees of oxidation facilitates formation or reduction into a condition adapted for speedy polarisation by electric currents. Although the above proportions and materials are best adapted to ensure rapid formation, any suitable framework or binding agent may be used in combination with the above mixtures or compounds. After the pulp and metal have been well mixed together in the presence of water, the compound or mixture is, whilst moist, spread or laid on one or both, preferably both, sides of a thin plate of lead platinum, or suitable material, to form a coating of about one-eighth of an inch thick." The number of the patent is 4809, 10th October, 1882.

Compass Deviatons.—Staff-Commander E. W. Creak, R.N., recently communicated a paper to the Royal Society "On the changes which take place in the deviations of the standard compass in the iron armour-plated, iron, and composite built ships of the Royal Navy on a considerable change of magnetic latitude." The general conclusions arrived at by the author are as follow:—1. A large proportion of the semicircular deviation is due to permanent magnetism in hard iron. 2. A large proportion of the semicircular deviation may be reduced to zero, or corrected for all magnetic latitudes, by fixing a hard steel bar magnet or magnets in the compass pillar, in opposition to, and of equal force to the forces producing that deviation. 3. A very small proportion of the semicircular deviation is due to sub-permanent magnetism, which diminishes slowly by lapse of time. 4. The sub-permanent magnetism produces deviation in the same direction as the permanent magnetism in hard iron, except when temporarily disturbed (1) by the ship's remaining in a constant position with respect to the magnetic meridian for several days, (2) by concussion, or (3) by both combined, when the disturbance is intensified. 5. To ascertain the full value of changes in the sub-permanent magnetism, observations should be taken immediately on the removal of the inducing cause. 6. In the usual place of the standard compass the deviation caused by transient vertical induction in soft iron is small, and of the same value (nearly) for ships of similar construction. 7. The preceding conclusions point to the conditions which should govern the selection of a suitable position for the standard compass with regard to surrounding iron in the ship.

A New Photometer.—A new and simple form of photometer has recently been designed by Mr. F. W. Hartley, of Millbank-street, Westminster. We take the following description of it from the *Journal of Gas Lighting*:—"It is intended for the easy measurement, in any situation, of the illuminating power of lights of any size, in any position, in the horizontal plane of the instrument or at an angle with it. The first instrument of this class has been made and used for the tests of burners now in progress in connection with the judging of the exhibits at the Crystal Palace. The examiners have found the arrangement so convenient that they now use it exclusively for the purpose with the Methven 2-candle screen. The latter standard, from its handiness, presents itself as the right one for a simple and, withal, exact appliance of this class, although, of course, any other is suitable. The apparatus consists of a table with two long slots in its surface. In one of these lies a movable scale, graduated in inches and tenths; and in the other slides the standard light by means of a winch. The light to be tested stands quite apart from the table, and according to its intensity may be 20, 30, 50, or 100 inches horizontally or diagonally from the screen when adjusted to zero of the scale. For all these determinate ranges, which give the operator the power of testing with a two-candle standard a light up to 555·6 candle-power, there are tables provided to obviate the necessity of calculation; although, as the readings are in linear measurements, the range of the instrument may be increased to any required extent. For angular measurements, Mr. Hartley has devised a scale for determining the hypothenuse, or the direct path of the light-rays to the photometer disc, which is a noteworthy addition to the handiness of the whole arrangement."

Self-Regulating Dynamos.—We take the following from Patent No. 4810, dated Oct. 10, 1882, and granted to Messrs. R. E. B. Crompton and Gisbert Kapp, which relates to their method of compound winding for dynamos:—"One method of carrying out this compound winding is to take a dynamo electric machine having an armature resistance of say 0·1 ohm, and wind on to its field magnets next to the core sufficient turns of No. 5 B.W.G. wire to give a resistance equal to that of the armature or 0·1 ohm or thereabouts and couple these coils in series circuit with the armature in the ordinary manner. Outside these coils we wind on sufficient ·057" wire to give a resistance of 20 ohms or from that to 30 ohms. We couple up this second winding of fine wire from brush to brush. Such an armature we prefer to drive at such speed that the electromotive force when the resistance of the external circuit is infinite will be about 65 volts. It will be found that if the external circuit be now closed through resistances varying from infinity down to 0·75 ohm, so that the current in the armature varies from two amperes up to 80 amperes, the electromotive force between terminals will remain nearly constant at the above named 65 volts. Moreover, that the magnet charge or extra current of the short length of low resistance coils will be so small that 40 or 50 lamps may be switched simultaneously out of the main circuit without producing any momentarily hurtful increase of current in one lamp left in circuit. This compound winding of the field magnets of dynamo electric machines has the further advantage of reducing sparking and wear of commutator and brushes to a minimum, as it always maintains a due proportion between the strength of the fixed magnetic field and the distorting influence of the induced field of the rotating armature."

H.M.S. "Himalaya."—This well-known troopship, which was lighted throughout with incandescent lamps by the Swan United Electric Light Company some six months ago, has just sailed on another outward voyage. Since the incandescent system was established on board her she has been to China and back, and traversed some of the hottest regions of the globe. It is satisfactory, therefore, to all interested in the electric light, and particularly the incandescent system, to learn that her officers were able on their return to send in to the Admiralty a most favourable report of the lighting. It was estimated that the lamps were in use for fully 1,000 hours, and this is probably well within the mark. The breakages only amounted to 25 lamps out of a total in use of 240. These figures speak for themselves. It is also very satisfactory, and affords evidence of good workmanship, to hear that, although a careful inspection of the whole installation was made on the ship's return from her four months'

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voyage, no repairs or overhauling were found to be necessary. In connection with the above ship an interesting experiment was made just before she sailed on the 26th May. Experience in Egypt in the disembarkation of troops by the electric light has induced the Admiralty to consider the question of supplementing the interior lighting with deck lamps hung in the rigging. In order to retain as far as possible the simplicity of the system, it was determined to try a group of incandescent lamps in preference to an arc lamp. For this purpose two regulation ship's lanterns were fitted with eight 50 candle-power Swan lamps each. The result obtained exceeded all expectation, for though the actual rays of light were not, of course, as powerful as with an arc, the general decision was that, owing to the equal distribution of the incandescent system, it was a more thoroughly practical light to work by, and we understand that it is highly probable that a similar system will be adopted in future cases.

The Electric Light on Brooklyn Bridge.—The first experimental test of the electric light installation on Brooklyn Bridge was made on Saturday, 19th May, says the last issue of *The Electrical World*, which we have just received. Everything was found to be in excellent order and the system worked to perfection. The United States Electric Illuminating Company is to be congratulated on its success in carrying out this piece of electrical engineering. The 70 lights are divided into two distinct circuits of 35 lights each. There are two separate engines, one for each circuit. The lights are so distributed on each circuit that in the event of the stoppage of one engine the light produced by the lamps on the other circuit will be equally distributed over the whole bridge. Each engine will serve to work two 20-light dynamo electric machines connected in series, which will furnish the current necessary for each circuit. The machines differ from the ordinary arc light machines in the fact that their magnetic fields are wound in derivation. The total length of the leading wires is said to be 30,000ft. The wire used is No. 3 of copper, braided, covered with kerite and painted so as to be absolutely proof against short circuits from contacts at any point with ironwork, and so that they may be protected effectually from water. The conductors are sunk in pipes and masonry along the approaches, and are secreted in wooden boxes along the bridgeway. There are also over 1,000ft. of small wire for the four station lamps. The lamps are all double, so as to accommodate two sets of carbons, and this will give them a capacity for burning in winter from 4:30 p.m. to 6 a.m. Their light-giving intensity is 2,000 candles (nominal). The lamps are suitably protected by the wire netted globes, and are fastened to ornamental bars projecting from iron posts suitably provided for them. It is said that besides the continuous circuit there is a wire that goes to each lamp separately, and which is used for the purpose of lighting and extinguishing the lights.

Secondary Batteries and Electric Lighting.—Mr. Lane-Fox's Patent.—On Friday, the 1st inst., before the Solicitor-General, Mr. Lane-Fox made application for leave to disclaim from his patent for the employment of secondary batteries in electric lighting, which is dated 9th October, 1878, all the claims originally made by him except that which covers the employment of secondary batteries in combination with parallel arc distribution as described in his specification. His application was opposed by the Swan United Electric Light Company, Messrs. R. E. Crompton and Co., and the British Electric Light Company upon various grounds, among which were that the invention to which Mr. Lane-Fox wished to limit his patent by the proposed disclaimer was wanting in novelty, that it was not the proper subject for a patent, that it was not sufficiently described in his provisional specification, and that the proposed disclaimer would alter the character of the patent. Mr. Webster, Q.C., and Mr. Moulton (instructed by Messrs. Grover and Humphreys, solicitors, and Mr. J. C. Mewburn, patent agent) appeared for Mr. Lane-Fox in support of the disclaimer. Mr. Aston, Q.C., and M. Chadwyck Healey (instructed by Mr. J. H. Johnson, solicitor) appeared for the Swan United Company; Mr. Aston, Q.C., and Mr. Phipson Beale (instructed by Messrs. Brooks and Son, patent agents) for Messrs. R. E. Crompton and Co., and Mr. E. Carpmael (instructed by Messrs. Wilson, Bristows, and Carpmael, solicitors) for the British Electric Light Company. Evidence in support of the disclaimer was given by Mr. Lane-Fox, the patentee, Professor Fleeming Jenkin, F.R.S., Professor Silvanus Thompson, D.Sc., and Mr. R. Sabine, and in support of the several oppositions by Mr. J. W. Swan, Mr. R. E. Crompton, Dr. Hopkinson, F.R.S., Mr. W. H. Preece, F.R.S., Professor Ayrton, F.R.S., Professor Oliver Lodge, Mr. D. G. Fitz-Gerald, and Hon. R. Brougham. After a long hearing the Solicitor-General decided to grant Mr. Lane-Fox's application for leave to disclaim. The claim under this patent will, therefore, be for the employment, as described in the specification, of secondary batteries as reservoirs of electricity in combination with a mode or system of distribution such as is therein explained.

Electric Lighting for Aberdeen.—At a meeting of the Town Council of Aberdeen, held on Monday last, considerable discussion arose on the provisional order that the council has applied for. It appeared from the statement of the Lord Provost to the meeting that the council applied for a provisional order some months ago, but that the Board of Trade would not sanction it, and sent down a model order embodying the clauses and conditions that they would be prepared to sanction. Not having time to consider this model order at a full meeting, the council sent a deputation to the Board of Trade, to lay their objections to it before Mr. Chamberlain. The result of their interview with this gentleman was the drawing up of the following amendments to the order which the Lord Provost asked the council to pass These were (1.) That no maximum price shall be fixed in the order, but that the undertakers shall be required to supply electricity at the cost of its manufacture, including therein charges for interest and for sinking and reserve funds, &c., in terms of the draft clause submitted by them to the Board of Trade. (2). That before the undertakers are required to supply any part of the compulsory area in schedule A a requisition signed by the owners and occupiers of one-fourth of the premises along a street or part of a street within such area shall be served on them, and that the owners and occupiers signing such a requisition, or some of them, shall be bound to take a supply of electricity for three years to the extent and giving security as in Section 23 of the proposed order. If the Board of Trade would not give effect to those amendments, then, the Lord Provost said, the Town Council would withdraw their order, and content themselves with watching the Brush Company, who have also applied for an order. A discussion arose on the Lord Provost's statement, in which everyone agreed that it was not quite right that the whole community should be taxed in order that a section of them should enjoy the benefit of the electric light. In the end a motion to the effect that the council was prepared to accept the provisional order if the above-mentioned amendments were given effect to was passed by 17 to 4. If the Board of Trade do not comply with the council's request, then the order will not be proceeded with.

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ELEMENTARY ELECTRICITY.—XI.

(CONTINUED FROM PAGE 57.)

In 1843 Prince Louis Napoleon, then a prisoner, writing to Arago, described two forms of battery in which only one metal was employed, so that there was nowhere a contact of dissimilar metals. The first consisted of a copper plate immersed in dilute nitric acid (which acts strongly on the copper), contained in a porous cell. The porous cell was placed in a jar containing dilute sulphuric acid in which was immersed a second copper plate. On connecting the plates with a galvanometer, a current flowed through the galvanometer from the plate immersed in the sulphuric acid to that immersed in the nitric acid. With a battery consisting of two of these cells he decomposed potassic iodide and cupric sulphate. The second battery consisted of two zinc plates, one immersed in dilute sulphuric acid contained in a porous pot, and the other in tepid water in a vessel surrounding the porous pot. This battery produced effects similar to that just described.

Napoleon then attempted to reverse "the usual order of the metals" (*i.e.*, Volta's contact series). He placed a copper plate in dilute nitric acid contained in a porous jar, while a plate of zinc was placed in pure (?) water surrounding the porous jar. On connecting the metals a current flowed from the zinc to the copper through the wire. These experiments alone seem sufficient to condemn the contact theory, as held by those who maintain that the electromotive force of a battery is due simply to the contact of dissimilar metals. More recently several other forms of battery have been devised, in which there is no contact of dissimilar metals. Napoleon complained that he was unable to measure the electromotive force of his batteries, as the iron bars of his prison interfered with his galvanometers.

If we suppose that when zinc and sulphuric acid are in contact and in equilibrium the potential of the acid is very much greater than that of the zinc, and similarly in the case of copper and sulphuric acid, the potential of the acid is much greater than that of the copper, but the difference in the case of the copper is less than in the case of the zinc, while we further suppose, as indicated by the Peltier effect, that there is no sensible difference of potential between copper and zinc when in contact, we can explain the action of the voltaic cell.

Suppose a plate of copper and a plate of zinc to be immersed in sulphuric acid, but no contact to be made between the plates. Then the acid must be at the same potential throughout, or it could not be in electrical equilibrium. Hence, since the difference of potential between the acid and the zinc is greater than that between the acid and the copper, the potential of the zinc plate will be lower than that of the copper and a quadrant electrometer would be capable of measuring this difference of potential which will be the electromotive force of the cell. If the copper and zinc are connected by a wire a current will flow from the copper to the zinc along the wire, lowering the potential of the copper and raising that of the zinc, so that the equilibrium between the metals and the acid becomes disturbed, electricity flows from the zinc to the acid and from the acid to the copper, so that the potential of the acid near the zinc is raised above that of the acid near the copper, and a current therefore flows through the acid from the zinc to the copper, thus completing the circuit.

If a plate of copper and a plate of zinc be connected together, and the free end of the copper plate dipped into one vessel of dilute sulphuric acid and the free end of the zinc plate into another vessel of the same liquid, the acid into which the zinc is dipped will be at a higher potential than that into which the copper is dipped. If now a connection is made between the two vessels of acid, by inverting a syphon filled with acid so that one leg is in one vessel and the other in the other, electricity must flow from the acid in the vessel in which the zinc dips to that in the other vessel, the equilibrium will be disturbed and a continuous current will flow through the circuit as before.

In the frictional electric machines, in the Voss and Holtz machines, in the replenisher and electrophorus the electrical energy developed is derived from the work done by the agent in overcoming the electrical attractions and keeping the machine in motion, or, in the case of the electrophorus, in raising the carrier plate in opposition to the attraction of the electrified ebonite. In the case of a thermo-electric couple, as will be explained under the head of thermo-electricity, the energy of the current is derived from the heat absorbed at the hot junction on account of the Peltier effect, or absorbed as the current flows from hot to cold or cold to hot along the metals on account of the Thomson effect. In the Voltaic circuit the energy of the current is derived from the chemical action which takes place between the metals, or one of the metals, and the acid (or electrolyte). That the energy of the current in ordinary batteries is due to the solution of the zinc in the acid was shown by Dr. Joule, who determined the amount of heat developed by a pound of zinc in sulphuric acid. He then immersed a battery in a calorimeter, and determined the whole amount of heat developed for each pound of zinc dissolved when the wire through which the current flowed was wholly contained within the calorimeter. The amount of heat so obtained was the same as when the zinc was dissolved in the acid without the production of any current. On causing the current from the battery to pass out of the calorimeter and to flow through a wire immersed in a second calorimeter the heat developed in the battery for each pound of zinc dissolved was less than before, but the deficiency was exactly compensated by the heat developed by the current in the external wire, and communicated to the water of the second calorimeter. From these experiments it appears that when a battery is employed in sending a current the heat corresponding to the chemical action taking place in the battery is not wholly developed within the battery, but a portion of it is employed in making the current flow through the circuit, and is reconverted into heat wherever the current does work against resistance.

We have already spoken of the electromotive force of a battery, but have not yet formally defined it. The electromotive force between two points is the same as the difference of potential between them, and is measured by the number of units of work done by the electric forces on the unit of electricity in passing from the first point to the second. Thus, if the terminals of a battery are disconnected so that no current is passing, the electromotive force between its terminals is the same as the difference of potential between them, and is represented by the number of units of work which would be done on a unit of positive electricity in passing from the positive to the negative terminal. This is called the electromotive force of the battery when insulated. It can be measured by connecting the terminals of the battery with the quadrants of an electrometer.

When the terminals of a battery are connected so that a current is flowing, the electromotive force of the battery is measured by the number of units of work done by the electric forces on the unit of positive electricity as it passes once round the circuit. The electromotive force of the battery under these circumstances will not in general be the same as when the battery is insulated, on account of the polarisation produced by the current. The cause of this difference, and and the method of measuring the electromotive force of the battery under these circumstances will be explained later on. The letters E.M.F. are frequently used as an abbreviation for electromotive force.

Faraday showed that when a pound of zinc is dissolved in a battery a definite quantity of electricity passes round the circuit. This will be referred to again in speaking of Faraday's law of electro-chemical equivalents. The electromotive force of the battery is the number of units of work done on the unit of electricity in going round the circuit. Hence when a pound of zinc is dissolved in a single cell, the electrical work done is proportional to the E.M.F. of the cell, being equal to the product of this E.M.F., and the number of units of electricity which flow round the circuit for each pound of zinc dissolved, and which is the same for all batteries. Now it is clear that this work cannot exceed the energy developed by the whole amount of chemical action

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which takes place in the cell in consequence of the solution of the pound of zinc. Thus the nature of the chemical action taking place in the cell fixes a superior limit to the E.M.F. obtainable therefrom. For example, if zinc is dissolved and free hydrogen liberated, the work done in the cell is that due to the combination of zinc with sulphion, (SO_4) diminished by the energy absorbed in liberating the equivalent of hydrogen from the sulphuric acid. If instead of liberating the hydrogen as free gas it is allowed to combine with oxygen (*i.e.*, burnt) within the battery, the work done by the combination of the zinc with the sulphion will not have to be diminished by so large a quantity, and the E.M.F. of the cell may be considerably increased. Thus, in Grove's cell, in which the liberated hydrogen is burnt at the expense of the oxygen of nitric acid, and in the "bichromate battery" in which the hydrogen combines with the oxygen of potassic bichromate, the E.M.F. is greater than that which would be developed if the same plates (zinc and platinum or zinc and carbon) were simply plunged in dilute sulphuric acid. These batteries will shortly be described, but before entering into a detailed description of them we must study some of the properties of the electric current, and the conditions upon which its magnitude depends. We shall then be in a position to state the objects which must be secured in a battery, that it may be suitable for any given purpose, and to see how and to what extent these conditions are fulfilled in the several batteries which we shall consider.

Electromotive force has already been defined. This may be regarded as that which produces the flow of electricity which constitutes a current. A current in a conductor is measured by the number of units of electricity which flow across any transverse section of the conductor in a second, and this is sufficient to completely define the strength of the current, just as a current of water may be measured by the number of gallons of water passing any transverse section of the conduit in a second. But, in the case of the steady flow of water, a given "head" of water will not be able to produce more than a certain current in a given pipe, and this current will depend on the length and section of the pipe, and on the comparative roughness or smoothness of its internal surface. In the same way a given electromotive force will not produce more than a certain electric current in a given circuit. The property of the circuit which limits the amount of current produced by a given electromotive force is called the *resistance* of the circuit. If a circuit could be found having no resistance, a finite electromotive force would produce in it an infinite current, and since the number of units of work done on each unit of electricity in going round the circuit is equal to the measure of the electromotive force, the amount of work done in a second by a finite electromotive force sending an infinite current would be infinite. Hence we have the following definition of resistance :—

DEF.—The resistance of a conductor is that property in virtue of which a finite electromotive force is incapable of doing more than a finite amount of work in a second in sending electricity through the conductor.

The definition of the *measure* of the resistance of a conductor, involving, as it does, the relation between the electromotive force between the extremities of a conductor or around a closed circuit, and the current produced therein is involved in the statement of Ohm's law. This definition, together with the actual *law implied* in the statement, will be considered in the next paper.

(TO BE CONTINUED.)

ELECTRIC LIGHTING AND THE ITALIAN ADMIRALTY.—A contemporary says that a trial of electric light was recently made on board the vessel, "Custozza," before the officials of the Italian Admiralty and a special commission, with good results. The installation was carried out by Messrs. Braun and Heider, of Pola, the machines and apparatus being supplied by Messrs. Ganz and Co., of Pesth.

SOME ELECTROSTATIC AND MAGNETIC RELATIONS.

BY OLIVER HEAVISIDE.

(CONTINUED FROM PAGE 55.)

18. What is, however, of greater importance than the mere symbolical identity of the operations is the physical interpretation that may be assigned to the different kinds of space variation. Operating upon an arbitrary vector function we obtain the scalar convergence and the vector curl; thus from magnetic force we obtain the density of magnetism and of current. That is to say, there are certain invariable relations between the space-variation of the magnetic force about any point, and the density of magnetism and of current at that point, which are most comprehensively stated in saying that the amount of magnetism within any space, which may be large or small, equals the whole amount of magnetic force leaving the space through its surface, and that the total current passing through any closed curve equals the line-integral, or the circulation of the magnetic force along the curve in making one complete circuit. But instead of such an abstraction as magnetic force, let us suppose that our vector function is of the simplest conceivable type, that it represents the continuous displacements of the particles of a continuous mass. Selecting any particle, the straight line drawn from its original to its final position is its displacement. The displacements of all the points constitute the vector system, or, expressed mathematically, the vector function. In estimating the space variation of the displacement, we have to examine the manner in which it varies in the neighbourhood of any particle O. In the first place the particle O with the surrounding particles may be displaced as a whole, a bodily translation in fact. This we disregard in considering the relative displacements, that is, we regard O as fixed. In the next place, the group of particles surrounding O may occupy a greater or less volume in the strained than in the unstrained state, *i.e.*, there may be expansion or compression. The expansion is estimated by finding the additional volume occupied in the strained state by the particles which occupied the unit volume in the unstrained state, and this is plainly to be done by finding the whole displacement outward through the surface of the unit volume; hence "divergence" in general, when applied to the special case of displacements, has the same meaning as the cubical expansion.

Again, the group of particles surrounding O may, during the act of displacement, suffer not merely the translation and the expansion, if any, but a rotation through a definite angle about a definite axis. Going back to the figure, let the displacements X be all perpendicular to the paper, say downward, and consider the variation of X about the point O. If O and the particles surrounding it are equally displaced, the matter in the plane of the paper about O is merely transferred bodily, remaining in a plane parallel to the paper; but should there be a greater displacement on one side than on the other, there will be rotation as well. Thus, if O R as before be the direction in which the displacement increases fastest, O R′ perpendicular thereto is the axis of rotation of the matter about O. Now O R′ represented our vector curl; consequently, interpreted for parallel displacements, the curl is the vector axis of rotation, and by elementary considerations its amount is twice the (small) angle of rotation. Hence, remembering the manner of composition of rotations, we see that the curl of the displacement function is a vector showing by its direction the resultant axis of rotation of the matter surrounding any point, and by its length twice the angle of rotation.

Also, it results from the analysis of the most general continuous displacements of a collection of particles, that the particles which originally occupied a small sphere with centre at O in the unstrained state occupy an ellipsoid after the displacements. The principal axes of the ellipsoid always correspond to a set of three rectangular lines in the original sphere, but there are two distinct cases. The three lines in the sphere may, as the sphere is turned into the ellipsoid, keep their directions unchanged, in which case the strain is

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pure, and may be produced by three rectangular compressions or elongations acting in directions parallel to the three lines. In the second case the three lines in the sphere do not keep their directions unchanged during the displacement, but are rotated as a whole about some axis. This is a rotational strain, and there is one definite manner of decomposing an arbitrary strain into the simultaneous effects of a pure strain and a rotation.

Thus, corresponding to divergence and curl, we have expansion and rotation. The condition of no divergence means, in the case of displacements, that the strain ellipsoid has the same volume as the corresponding sphere, and the condition of no curl implies that the strain is pure, or unaccompanied by rotation.

We have similar results when we consider not the displacements, but their rates of increase, *i.e.*, the velocities of the particles. Thus, the motion of a fluid may be rotational or irrotational at any place; in the latter case the curl of the velocity is *nil*, in the former its value is twice the angular velocity.

19. Electric current and its related quantities are all characterised by the absence of divergence. Their distributions are therefore similar to possible states of displacement of the particles of an incompressible solid, or of the instantaneous velocity of an incompressible liquid. There is also a common characteristic, that having no divergence anywhere they have necessarily curl somewhere, a property essentially connected with the existence of *closed* lines (of force, current, &c.). Let us suppose that we have a field of magnetic force, B_1, due to currents only, and that the force actually produces a small displacement in the medium where it acts, of amount proportional to the strength of force. A state of strain would be set up. In space unoccupied by current, curl $B_1 = C_1 = 0$, and the strain is pure. But where there is current, curl $B_1 = C_1$ is finite, and the strain is rotational, its axis is the direction of C_1, and the angle of rotation $\frac{1}{2} C_1$ in amount. In both cases, either within or without the current, div. $B_1 = 0$, or there is no expansion accompanying the strain.

The existence of the rotation (with the above assumption of displacement in the direction of B_1) is easily recognised in the case of a straight current. Let the wire be of circular section. The lines of force are circles in planes perpendicular to the axis, centred thereon. The strength of force increases from *nil* at the axis regularly to a maximum at the surface of the wire, being, anywhere between, proportional to the distance from the axis. If we then take a thin slice of the wire bounded by two parallel planes perpendicular to the axis, and displace its parts through very short distances proportional to and in the direction of the magnetic force at any place, the result will be a rotation of the slice *en masse* about the axis, as a wheel for example. It is easily seen also that the supposed displacements produce relative rotation of the same angular amount of any two points in the slice, and that besides the motion of translation as a whole of the particles surrounding a given point, there is the definite rotation about a line parallel to the axis of the wire. The rotations are equal, because we have tacitly assumed the current density to be uniform throughout the section of the wire. Outside the wire, however, the strength of force falls off, varying inversely as the distance from the axis. This distribution of force makes curl $B_1 = 0$, and the corresponding strain at any place where small displacements are produced by the force is unaccompanied by rotation, or the displacement is differentially irrotational. [We have used the word "strain" to include the case of mere rotation without distortion.]

20. But by far the most interesting analogue is that presented by the motion of a perfect incompressible liquid. Let it fill all space (since the magnetic force of our rectilinear current extends without limit), and replace lines of force by lines of motion of the liquid, its velocity to everywhere correspond to the strength of magnetic force. We have then a case of vortex motion. The liquid within the cylindrical space corresponding to the wire is rotating, every particle of it, with the same angular velocity. The motion of the liquid outside the vortex, however, although the lines of motion are circles about the vortex, is differentially irrotational—*i.e.*, particles which at a given moment occupy a very small sphere about a given point, at a very short time after occupy an ellipsoid of the same volume without rotation from one to the other. We might, from our knowledge of the relations between magnetic force and current, deduce some of the remarkable properties of vortex motion, so far as they do not involve the dynamics of the subject—*i.e.*, merely characteristics essentially connected with the motion. Current direction corresponds to the axis of a vortex, current density to twice the angular velocity; vortex lines and tubes, analogous to current lines and tubes, are always re-entrant; the line-integral of magnetic force about a current measuring the amount of current corresponds to the circulation of liquid about a vortex being proportional to the angular velocity of the latter, &c. But, not to go into details, we will merely note, further, the analogue of the identity $\frac{1}{2}\Sigma B_1^2 = \frac{1}{2}\Sigma \overline{A_1 C_1}$ (p. 391 ante). Here, B_1 being the magnetic force of current C_1, whose v.-potential is A_1, we have two expressions for the quantity that there is reason to believe is the kinetic energy of the system of magnetic force. Now, let B_1 be the velocity of a perfect liquid of unit density, then $\frac{1}{2} \Sigma B_1^2$ is really the kinetic energy of the whole motion (sum of mass of each elementary portion × $\frac{1}{2}$ square of its velocity). We have then the remarkable result that the kinetic energy of the moving liquid can be expressed in terms of its angular velocity in those places where the motion is rotational, and of the corresponding v.-potential. Further, since if $C_1 = 0$ everywhere, making $\Sigma \overline{A_1 C_1} = 0$, it follows that $\Sigma B_1^2 = 0$, which (being the sum of squares) involves $B_1 = 0$ everywhere. That is to say, if there is no rotation there can be no motion of the liquid. Hence, if the liquid fills all space, its motion, whatever it be, cannot be everywhere irrotational. When, however, the liquid is bounded, as by the surfaces of immersed solids, the motion of the liquid *may* be everywhere irrotational in itself. If so, the rotation is to be sought at the bounding surfaces, and there it will be found, being represented by the difference of the tangential motion of the liquid passing the surface of a solid and of the solid itself at the same place. Or we may reduce this to the former case by imagining the solid to (momentarily) become liquid like the rest, whilst the new liquid has the motion of the solid at the moment considered. There is now continuity of the normal components, and in general discontinuity of the tangential components of the motion of the liquid just within and just without the surface, which was that of the solid before it was melted, and, consequently, differential rotation at the surface. The latter, therefore, constitutes a vortex sheet, analogous to a current sheet, and the vortices are distributed just as the current would be in the current sheet, which would produce a field of magnetic force exactly corresponding to the actual state of motion of the liquid at the time.

21. A simple example is that of a spherical solid set in motion in a perfect liquid originally at rest. Let its velocity at any time be V parallel to *s*. The motion of the liquid exactly corresponds to the external magnetic force of the system of surface current over the sphere which would produce an internal field corresponding to the given internal motion, *i.e.*, a uniform field of strength V parallel to *s*. To find this system, we may notice that the curl of the magnetic force given, the internal uniform field, is purely superficial, of amount $V \sin \theta$ at any part of the surface whose angular distance is θ from the pole or most forward point of the sphere in motion. A system of circular currents over the surface, of strength $V \sin \theta$, with positive motion about the axis *s*, will be easily found to give a uniform internal field parallel to *s*, but only of strength $\frac{2}{3}$ V. Consequently, if we make the strength of current $\frac{3}{2} V \sin \theta$ we get the required internal field of strength V, and the corresponding external field will represent the liquid motion when we translate V as velocity.

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The added current corresponds to the external surface curl, of magnetic force or of velocity as the case may be. The external v.-potential of the surface current is $\frac{1}{2}\frac{Va^3}{r^2}\sin\theta$ at distance r directed perpendicular to r and s, the lines of v.-potential thus being also circles about s in planes normal to s. At the surface it becomes $\frac{1}{2}Va\sin\theta$, if a be the radius of the sphere, and coinciding in direction with the current. Hence we may easily find the energy, viz.:—

$$\frac{1}{2}\Sigma\overline{AC} = \frac{1}{2}\iint\frac{1}{2}Va\sin\theta.\frac{3}{2}V\sin\theta.\,a^2\,d\mu d\phi = V^2\pi a^3.$$

Of this $\frac{1}{3}$ is external, $\frac{2}{3}$ internal, as we may conclude from our having obtained twice as great internal as external surface curl, agreeing with the well known result that the kinetic energy of the liquid is one half that of the solid sphere which moves it if it has the same density. $V^2\pi a^3$ is in fact the whole energy in the electro-magnetic case, and also the whole energy in the case of the moving liquid, including that of the sphere of same density. The external magnetic force, or velocity, is the curl of the above v.-potential $\frac{1}{2}V\frac{a^3}{r^2}\sin\theta$. The scalar potential, on the other hand, is $\frac{1}{2}V\frac{a^3}{r^2}\cos\theta$, and its space-variation gives the magnetic force or the velocity at any point. This scalar potential is that of the magnet, which would give the same external force. It may be got by substituting a plane magnetic shell for each circular current. The whole collection of shells constitutes a sphere magnetised to intensity $\frac{3}{2}V$ parallel to s.

22. The other kind of magnetic force, B_2 above, arising from magnetism, possesses just the same characteristics as B_1 arising from currents, as regards the space external to the magnetised matter. In fact, given a space in which there is a given distribution of force, but quite devoid of current or of magnetisation, and given no knowledge of anything outside the space, it is impossible to say what the origin of the force is, whether magnetisation or current. No necessary distinction can be drawn under the mentioned circumstances. The sources external to the space considered might be either currents or magnetism. The lines of force of B_2, however, in a complete field, as well as in the incomplete field above, are unclosed, and hence arise important differences in the mathematical treatment. But this idea of magnetic force being due to magnetic matter, the residual or unneutralised polarity of the magnetisation, whilst perfectly accounting for the external force, is in all probability entirely erroneous as regards the force within a magnet, and so may be here dismissed, and the more complete theory of internal force will be considered later.

(TO BE CONTINUED.)

EXPERIMENTS WITH SECONDARY BATTERIES.

In the *Electrotechnische Zeitschrift* of May there is an interesting description of experiments on the charging and discharging of storage cells by Herr v. W. Hallwachs, which deserves attention both on account of the pains bestowed upon the observations of the conditions and of the conclusions at which the author has arrived, not always in accordance with current ideas. The elements used were four in number. Nos. I. and IV. were made by Herr Otto Schulze, and consist of a series of lead plates, of which the even numbers are connected together metallically, and also the odd numbers. No. I had five plates, on which 1kg. of red lead was spread, the plates being 20cm. high and 10cm. wide. Its weight with acid was 8·1kg. No. IV. had thirty plates, which were roughened and then spread with flowers of sulphur and warmed so that a coat of sulphide of lead was formed upon them. The weight of the element was 10·5kg. No. II. was an element of Tommasi, composed of two square frames 30 by 30cm., made of square lead rods, the space being filled with horizontal lead strips $\frac{3}{10}$mm. thick and 15mm. wide, packed close together. This element weighed 21·4kg. No. III. was an element of Bréguet, made of two sheets of lead separated by strips of caoutchouc, and rolled up into a cylindrical form and placed in a glass cylinder. It weighed 4·9kg. Both No. II. and No. III. were prepared by the Planté method. The fluid employed was sulphuric acid diluted with ten volumes of water.

The following table gives the result of the experiments:—

Charge.					Discharge.				
Element.	No. of Experiments.	T in Hours	(J_0)	L_e in 10^3 V.A.S.	r	t in Minutes.	l in 10^3 V.A.S.	(i_0)	N
I	2	10	6	800	0,22	123	224	10,1	0.28
I	5	1	19.4	110	0,132	5	7,1	13.2	0,06
I	6	4	3.9	122	0,138	15	26,0	13.0	0.21
I	7	4	17,1	533	1,136	590	130	1,8	0.24
I	8	4	1.1	33.7	1,137	12	2.0	1,7	0.06
I	9	13	1,0	95,3	1,137	48	8,6	1,6	0,09
I	10	4	6.9	225	1,137	178	33.7	1.6	0.105
I	11	4	7,2	235	1,137	435	87,8	1.7	0.37
I	12	4	10,8	363	1,136	647	126	1,7	0.35
I	13	7	7,4	434	1,136	900	175	1.7	0,40
I	14	1	6,7	51,3	1,142	128	23,0	1,6	0.45
I	15	4	8,3	276	0,500	303	137	3.8	0,50
I	16	4	4,0	133	0,135	36	62,0	13.5	0,47
I	17	4	6,6	219	0,195	93	108	9.4	0,49
I	20	4	4,0	132	0,135	39	63.7	13,2	0.48
I	22	4	4,2	141	0,118	27	39,5	13,2	0,28
III	18	3	6,1	161	0,135	7	13.6	14.7	0,08
II	21	4	4,1	138	0,135	21	31.6	12,6	0,23
II	23	4	4,0	126	0,113	23	40.8	14.3	0,32
IV	19	2,5	21,4	434	0,297	131	87,0	6,0	0,20
IV	24	4	3,6	109	0,118	25	44,1	14,8	0,405

J_0 represents the mean value of the charging current.
i_0 „ „ „ discharging current
T „ time of charging in hours.
t „ „ discharging in minutes.
L_e is the electrical work done against the E.M.F. of the cell in charging $\left\{=\int JE\,dT\right\}$ in terms of units, each of which is 1,000 B.A. units.
l = electrical work given out by the cell in discharging $\left\{=\int i.e.\,dt\right\}$ in the same units.
N is the ratio of l to L_e.
r is the external resistance when discharging.

The following are among the conclusions which the author draws from his experiments:—

On first beginning to charge the element the E.M.F. of the element increases very rapidly, at a rate depending on the value of the current, until it reaches a value varying from 2 to 2·4 volts. Then if the current is maintained constant the increase goes on slowly, and the author has not succeeded in reaching a point where it is a maximum under these conditions, though if the value of the current diminishes the E.M.F. of the element may fall. Fig. 1 illustrates this increase. Fig. 2 represents discharge. At the beginning the E.M.F. is about 2 volts. As the store of energy diminishes the E.M.F. falls, at first slowly, then more quickly, and afterwards very slowly, but never quite to zero.

The following experiments made with No. I. element show the variation of the E.M.F. with the strength of the charging current:—

Experiment.	J_0.	T.	E_e.
8	1·1	4	1·95
6	3·9	4	2·19
16	4·	4	2·27
14	6·7	1	2·20
13	7·4	7	2·33
7	17·1	4	2·46

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Then J_o E_o are mean values respectively of the current, and the E.M.F. of the element.

Experiment 14 shows clearly the effect on E_o of the duration of the period of charging.

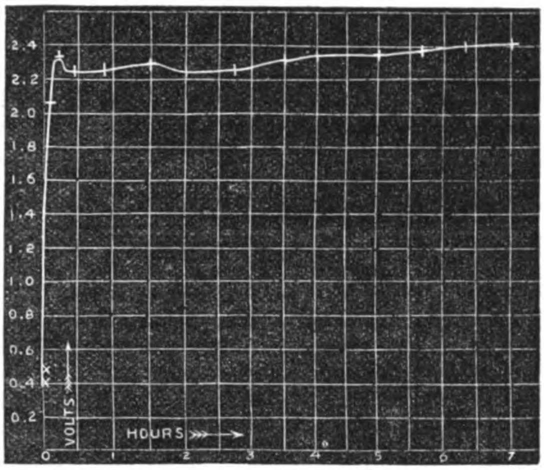


FIG. 1.—Showing increase of E.M.F. during charge.

The resistance of an element during charging sinks to a constant value, in the case of the elements used, as follows:—

Element I. ·009. to ·014 ohm.
„ II. ·020 to ·025 „
„ III. ·015 „
„ IV. ·015 „

During discharge the resistance is at first constant, but begins to increase proportionately to the lapse of time at the point where the E.M.F. begins to fall quickly.

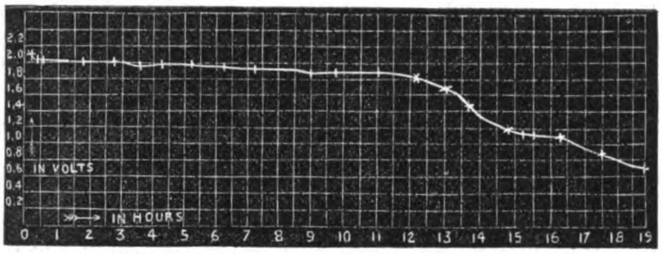


FIG. 2.—Showing fall of E.M.F. during discharge.

Figure 3 shows these effects.

The following experiments with No. I. element show the effect upon the efficiency (N) of its previous history and employment:—

Experiment.	N.	T.	J_o.	r.
6	·21	4	3·9	·138
16	·47	4	4	·135
20	·48	4	4	·135
22	·28	4	4·2	·118

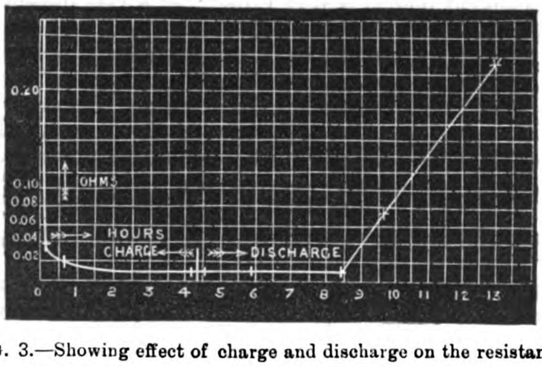


FIG. 3.—Showing effect of charge and discharge on the resistance.

Before Experiment 6 the element had been used for affording light for about two months, then after a month's rest had been charged and discharged some ten times. Between 6 and 16 it had been charged and discharged about twenty times, between 16 and 20 about four times, and between 20 and 22 twenty-seven times, with a pause of 12 hours after each charging. At the next charge the element broke up. The value of the charging current may be observed to affect the value of N, the efficiency, and in such a way that there is a certain value of the current for which the efficiency is a maximum. This value is between 4 and 11 amperes, but is not determined.

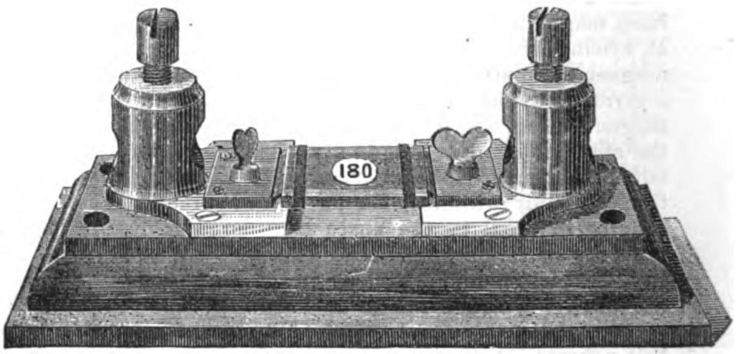
A long pause ensuing between the charge and discharge has a bad effect upon the efficiency, as may be gathered by comparing Experiments 10 and 11, in the first of which an interval of 14 hours' rest was allowed to elapse, during which the plates were removed from the liquid. The values of N in these two cases were ·10 and ·37 respectively.

The best value of N obtained was ·50, in Experiment 15. The value of the charging current was 8·3 amperes. In Experiment 13 the most work was obtained from the element, viz., 175,000 volt ampere seconds. This would be about 3,000 kilogrammeters per kilogram of electrodes.

HEDGES' PATENT CUT OUTS WITH FUSIBLE SAFETY PLUGS.

The use of safety plugs in all installations of the incandescent electric light is now a recognised necessity. Much annoyance has, however, been experienced by electricians on account of the frequent rupture of the piece of lead wire or bar of alloy, which has hitherto been used as the safety fuse.

Experiments show that any alloy of tin with lead or copper is useless on account of the rapid deterioration of the metal caused by the passage of the electric current, besides having the objection, common to all metals employed in a bar form, that, on account of inequality of the temperature, the moment of rupture is accompanied with noise and the scattering of the molten metal.



In Hedges' cut outs for sizes to take a current above 20 amperes the fuse consists of thin foils of special alloy, which is known as Albo metal, the area of the foils and the number being in proportion to the currents to be carried. The foils are separated and thoroughly insulated from each other by mica plates, so that the current is divided through the whole number, and the rupture takes place through the centre. The mica, not being affected, can be used over again.

For currents under 20 amperes a special cut out is designed, in which the foil is wrapped round a piece of mica and connected on each side to the two terminals, so that it can instantly be replaced, whereas, with lead wire, making the connection is a matter of difficulty. This form of fuse takes little space, and can be easily introduced into a small switch.

These foils have been in practical use at the new Law Courts since their opening, and some which have been employed the whole of the time show no deterioration. They can be safely worked within 10 per cent. of their melting point, but where the current is likely to be irregular it is better to allow a larger margin.

For secondary batteries they are extremely useful to prevent reversal of the current when the dynamos are stopped.

The cut-out illustrated above is supposed to contain a fuse which will melt with a current of 180 amperes. Mr. Killingworth Hedges of 25, Queen Anne's-gate, Westminster, is the designer of these cut outs.

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A TENDER FOR ELECTRIC LIGHTING.

We herewith give an estimate which has been furnished to the Vestry of St. Mary, Newington, by the Electric Carbon, Storage, and Apparatus Manufacturing Co. of Scotland for an installation of incandescent lamps. The Vestry have also prepared an estimate, which we give below :—

Company's Estimate for an Installation of

6,000 incandescent lamps of 16 candle-power.
50 do. 50 do.
Making a total candle-power of 98,500.
For which would be required 500 effective horse-power.

	£	s.	d.
Compound steam engines, with boilers, complete...	£3,600	0	0
Fixing ditto	200	0	0
Self-regulating safety dynamo machines complete.	3,000	0	0
Fixing ditto	50	0	0
Shafting and belting	150	0	0
Engine house	500	0	0
Altering present street lamps to suit electric light.	100	0	0
Main and branch leads, as shown on plan, with allowance for future extension to St. George's Church with Dr. Higgs's patent earth plate	2,000	0	0
Contingencies	500	0	0
	£10,140	0	0

Cost of Maintenance (Annual).

	£	s.	d.
1,690 tons of coal at 20s.	£1,690	0	0
1 manager	180	0	0
1 assistant	104	0	0
2 engine drivers at 30s.	156	0	0
2 engine stokers at 20s.	104	0	0
2 boys at 5s.	26	0	0
Oil, waste, water, &c.	300	0	0
	£2,560	0	0

Revenue.

	£	s.	d.
From 5,000 lamps at gas rate	£3,662	0	0
,, depôt gas account	160	0	0
,, public streets	205	0	0
Profit on sale of lamps, at 6d. each, say 6,000	150	0	0
	£4,177	0	0

	£	s.	d.
Annual revenue	£4,177	0	0
,, expenditure	2,560	0	0
Balance to carry forward to redemption of debt*	£1,617	0	0

Leith, May 16, 1883.

Dear Sir: In handing you this estimate, I am not actuated by primary motives of personal profit, but more to enable you to convince your ratepayers and the vestry of the enormous advantages they would derive from the adoption of a good system of electric lighting. I have read with pleasure your report and the remarks therein of Dr. Siemens and of Mr. Lane-Fox, both of whom are authorities of considerable experience, and their remarks deserve due attention. I must, however, take exception to the statement by Mr. Lane-Fox, "that with good machinery a combustion of 1¾lb. of coal will yield one horse-power per hour." In practice, and with the best machinery, 2lb. to 2½lb. of good Cardiff coal is required to yield one horse-power per hour. This I have proved by long experience with the best class compound engines. Also, with an economical dynamo, such as the one invented by Dr. Higgs, 200 candle power may safely be calculated per indicated h.-p. Dr. Siemens's figures, as regards the comparative cost of electricity as against gas, are convincing to an ordinary observer; and the only thing that remains is to instil confidence into the minds of the public, and you will have their hearty support in your endeavours in the direction in which I am glad to see you are moving.

You will see from the estimate which I have the honour to submit to you that the initial cost of the whole

	£	s.	d.
plant is	£10,140	0	0
The annual expenditure	2,560	0	0
The annual income	4,177	0	0
Leaving a balance of	1,617	0	0

clear profit, which will enable you to pay off your loan in less than 15 years with ease. Moreover, the profits are likely to exceed the estimated amount, for while the expenditure will remain almost stationary, the revenue from lighting will increase until, within three or four years, the whole 6,000 lamps will be called for, thus adding £1,000 per annum to the revenue.

Profit may also be derived from rent of meters, sales of fittings, and also from the use of electricity as motive power for driving sewing machines, and other light work.

Another important factor is the accumulator, without which you should not attempt house lighting, for it is not reasonable to expect your customer to consume what he pays for immediately he gets it; but he should be able to store the electricity for use when required, and also be able to use it for other purposes than lighting. You will see that I have estimated for the use of an earth plate for the return current; but if you prefer to have return wires, the cost would be £1,500 more.

The figures quoted, although approximate, are yet as nearly exact as it is possible to get; being rather over than under what an actual estimate would be; but should your vestry favour me with instructions for another estimate when you are prepared to go to work, I shall be most happy to go fully into the matter and quote you exact figures.

In reference to the system of lighting which is likely to prove most economical, I would point out that Dr. Higgs's dynamo is the only self-regulating one, and is the one which will be generally used so soon as its merits become known, as it is apparent to the most dull of comprehension that no system can be so economical which is not self-regulating.

I am in position to say that my company can offer you terms and facilities such as no other company has yet entertained, and at the same time give a full guarantee relieving you of all risk of failure. I have pleasure in enclosing copy of the report made by a deputation from the Bootle Town Council, knowing that it will be of interest to you, as being testimony from an independent and unbiased source.

I have confidence in thinking that these figures will convince the most determined opponent of the new illuminary that, from a purely commercial point of view, it will repay the outlay with interest, and even if this were not the case, and the electric light proved to be, light for light, more expensive than gas, yet there are other considerations to take into account. Is it nothing to be free from the danger of explosion and fire; nothing to be free from the overbearing heat and poisonous fumes, and the constant flicker of gas; nothing to have the atmosphere of our homes once more pure and free from the smokiness of gas? I think these advantages far outweigh any question of £ s. d.; but when these advantages are coupled with economy, surely it can be only madness that would refuse to discard the conservatism that would poison our bodies and burn our homes, rather than advance into the soft, soothing, and economical light of electricity.—Yours truly, John Evans Jackson,
Manager Elec. Carbon, &c., Co.

To L. J. Dunham, Esq., Walworth.

Vestry's Estimate for the Installation.

	£	s.	d.
Four 150 h.-p. engines, including boilers, setting and connections, at £9 per h.-p.	£5,400	0	0
For building shaft, &c.	1,000	0	0
Four dynamo machines, equal to 1,500 lights each, at 15s. per light	4,500	0	0
Fixing bands, connections and sundries	1,200	0	0
Cables, main electric lines and testing boxes, &c., from the depôt to the extreme limits of the compulsory district, provision being made to lay down a sufficient line to extend the supply to St. George's Church when required	6,000	0	0
Exchange of lamp posts, columns, and lanterns throughout the compulsory district, providing for new lamps and fittings for same	500	0	0
Lamps, columns, and necessary fittings for the street lighting between the depôt and the railway bridge, including necessary lamps and fittings for providing and supplying of electricity to the Vestry Hall and depôt	500	0	0
Contingencies	900	0	0
	£20,000	0	0

Maintenance Charges.

	£	s.	d.
1,690 tons of coal at 20s.	£1,690	0	0
One electrician	250	0	0
One assistant (outside) at	104	0	0
Two engine drivers at 50s. per week	260	0	0
Two stokers at 30s. each per week	234	0	0
One assistant in engineer's room	52	0	0
Oil, waste, water, bands, &c.	550	0	0
	£3,140	0	0

	£	s.	d.
Annual revenue	4,027	0	0
Annual expenditure	3,140	0	0
Balance to carry forward in payment of interest, &c.	£887	0	0

* The interest and instalment for the first year on a loan of £15,000, taken at 3½ per cent., would be £1,525.

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ANSWERS TO CORRESPONDENTS.

AMATEUR.—*We do not think the author will go into the details of the construction of the instruments you mention. There are no books published of the kind you require. Culley's Handbook will give you a large amount of information as regards practical telegraphy, so will Preece and Sievewright's. Kempe's book on testing is the best of its kind, and we hear that a new edition will shortly appear. We think most of the information you seek has at various times been given in our columns.*

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FINANCIAL PAPERS AND THE TELEPHONE COMPANIES.

We do not know that it is our duty to attempt to understand the reasoning of some of the financial papers when they discuss the commercial side of telephonic interests, but whilst caring little about the wire pulling for speculative purposes we must for the sake of *bonâ fide* investors declaim against unjust criticism. The general idea which seems to pervade the minds of the conductors of some of these financial papers is to slap away at everything electrical. It is sufficient that the market is depressed. It is known that great efforts are being made to keep going some large but wholly unsound concerns, but why a more judicious spirit in regard to other, to say the least, not wholly unsound concerns, should not prevail it is difficult to see. Admitting that speculators have reaped a harvest, admitting that they have well worked upon the credulity of the public, we must admit, nay, we will speak more strongly, we know, that some of the electrical companies are founded and are being worked upon the soundest business principles. Our opinion is that honest writers attempt to give an honest criticism, and that a financial paper which allows its columns to be one sided is never again to be trusted. Mistaken conclusions may always arise, but intentional inuendoes are far from creditable. We have had our attention called to a recent article upon telephone companies which we think is calculated to mislead many of its readers. Several companies are referred to, but we do not think sufficient care has been taken to show the vast difference between the one company and another. Each will be looked upon as equally bad; but is this so? Here is a sentence:—"The profit and loss of this company shows, *as we make it* (the italics are ours), a net loss in working of £2,960, whilst it is pleasant to think that the directors pocketed £1,500 in fees." Evidently the writer means to insinuate that if a concern does not pay the directors are not to be paid for their work. Apply this conclusion to newspaper editors, and see how they would like it. Is a company to prove a veritable Golconda, and must it pay upon its first real year of work? A more just criticism would have been one against the number of directors. Is it customary, too, with financial papers to put the whole cost of formation, building, &c., to one year's account, or is it usual to spread this cost over a number of years? In the balance-sheet criticised the "cost" is spread over a number of years; in the financial paper the "cost" is "lumped" into one year. It is admitted that this company—it is the Oriental Telephone Company, whose report appeared in our last issue, that we more especially refer to—is not in a present perilous position. This, however, is not the question before us, which, to put it plainly, is whether it is just to mix up criticisms and figures so as to tend to mislead the public. We have been slightly amused over the report of this company; in fact, most reports are to us amusing, it may perhaps be because of idiosyncrasies leading our thoughts more to the scientific than to the commercial. Directors are told that the dividend is made partially by a return of a premium paid by shareholders upon shares. No doubt; but do the shareholders expect the directors to do their best to make money when they can? Do they expect that if a premium is to be had the directors will refuse it because it adds to the profits? Then the financial papers criticise because something has been sold and increases the profit account. We would ask whether the directors are not elected to make a good bargain for the shareholders when they see a chance. We are politely told that a man with special knowledge, with special means of benefiting a company, should not be a director, because he is connected with another concern. Is it not a little too palpable that the logic of this argument is weak if put in other ways? Shall we say that Brown, Jones, or Robinson is ineligible to be a director of an iron works in New Zealand because he is a director of an iron works in Yorkshire? Why should not a man be a director of a "Cotton Mill Company" in Lancashire, of one in Bombay, and of one in the States? We do not pretend to see further through a brick wall than most people, and hence, we suppose, are unable to find a reason why such a state of things should not be. Put it another way. Jones purchases the patent of a bicycle. Is he ineligible to be a director of a bicycle company in New Zealand because he is a director in a bicycle manufacturing company in England, and hence interested in the promotion of such branch companies? The whole theory of this ineligibility is absurd unless the one company be by some means antagonistic to the other, and a a profit to the one means a loss to the other, or the director

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has not the time to attend properly to the duties he has undertaken.

The report of the Oriental Company did not strike us in the same light as it seems to have been seen by our contemporary. We have long since expressed our views as to the prices paid for patent rights; but investors took little notice of the warnings of the scientific press. They have paid for their patent rights, and they know it, so why should they grumble now, when no objection was made at the time, when, in fact, the sole idea seemed to be to get the shares. Having sunk their money, the question is so to work as to get a fair return, and we fail to see where this question has not been constantly before the eyes of the directors of the company whose report we refer to. They have opened up exchanges at various places in the East, their list of subscribers is gradually extending, and there seems every prospect that a good profit will be made upon this exchange work. It takes time to establish exchanges, and at this early period of the company's work it is more the future prospects than present results that fixes attention, and according to the report these prospects are very good. We have preferred to deal more directly with the question of telephone companies than with electric light companies, because of the report and criticisms before us, and because we think that telephony must and will become as universal as telegraphy. There seems hardly any end to its development, and when a company has erected wires it does not much matter if science improves upon the instruments in use. The instruments used merely for the speaking or receiving are answerable for but a comparatively small part of the expense in connection with telephone exchanges, and the cost of replacing them with improved forms would not be excessive. The policy of directors should be closely watched, but they are surely justified in using every legitimate means to improve the company's position and to gain a dividend for the shareholders. The development of the exchanges is purely a question of time if the position of the exchanges has been wisely made, and the greater the number of exchanges the less becomes the dead weight of cost of patent rights. We again say that, while ready to acknowledge any praiseworthy efforts to show up rotten companies, we cannot support a policy that showers disparagement upon all alike. The market electrical is greatly depressed, and justly so, but surely that is a reason why financial advisers should endeavour to weigh justly every fact, and, where possible, to show the possibility, by judicious management, of a brighter future.

CORRESPONDENCE.

LECLANCHÉ CELLS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I notice in your issue of May 26 that the writer of the articles on "Practical Telephony" strongly recommends the adoption of the prism form of the Leclanché cell, but I think that in practice the battery will not be found so good as the old form of Leclanché with the porous cell. Its chief virtue, of course, is its low internal resistance; but that is scarcely an advantage on a ringing circuit, while from the form of the india rubber band employed to bind the couple together local action is set up by impurities detached from the block and settling thereon, thus soon completely destroying the zinc. This form is dirtier to handle, with more risk of breakage, than the ordinary form, whilst from my observation it also "polarises" quicker on a short circuit.—Yours, &c.,

HAROLD DOWSON.

IMPROVEMENTS IN FAULT LOCALISATION TESTS BY FALL OF POTENTIAL.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Permit me to occupy a space in your columns on a subject of great interest and greater practical value, one whose main features are already well known to the electrical world, but whose developments have not yet, it appears to me, received the attention they merit.

A method for localising a single fault in a single cable by observing the fall of potential through a part of it under certain conditions of electromotive force and resistance at one end, appears to have been invented by Mr. Latimer Clark comparatively early in the annals of electrical testing. This arrangement, now well known, is seen in the accompanying figure.

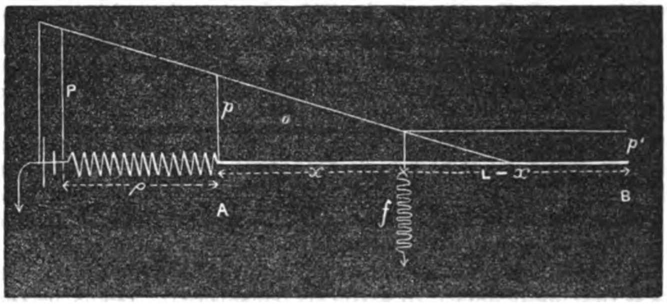

FIG. 1.

At the same moment the potentials P, p, and p' are observed, represented in the figure by ordinates erected on the circuit line at those points.

Then x, the distance of the fault from A in ohms

$$= \rho\left(\frac{p - p'}{P - p}\right) \quad . \; . \; . \; . \; . \; . \; . \; . \; . \; . \; . \; . \; . \; . \quad \text{(I.)}$$

This test, when carefully carried out, is most effective, and has often yielded very accurate results, but it has two weak points in its published form. These we will examine in detail.

It is generally found in practice that as regards measuring instruments at station A one is employed in preference to two. Firstly, it seldom happens that two electrometers are available at one station; or, if high resistances and galvanometers are employed in their stead, the necessary high resistances which can be collected seldom suffice for both galvanometers. Secondly, if even separate instruments for both potentials be forthcoming, it is well known that under the conditions of this test more error is likely to be introduced into the calculation in obtaining the relative value of their deflections than probably the dual observation will expel. One instrument is therefore placed in connection with the ends of the resistance ρ alternately, and time being always thus lost in the intervals, any change taking place during the test in the fault's resistance is only revealed in A's observation *per saltum*, while B's are continuous. Correction can, of course, be made for the want of continuity in A's readings, but only when the change taking place is steady, which is seldom quite the case. Consequently, error is introduced into the results through want of synchronism in the readings at each end.

The chief objection, however, is that the test is not a "null method." It has long been known, and the subject has lately received the attention of noted physicists, that far greater accuracy is attainable in electrical measurements when zero values have to be indicated than when a particular positive or negative value has to be observed. To this the accuracy of the Wheatstone bridge has well been ascribed. In other words, it seems that the conditions of the matter employed in measuring instruments are such that statical equilibrium is more readily detected than dynamical moment of any stated amount.

In this particular test none of the quantities P, p, and p'

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are zero in measurement, for if p' be zero the fault's resistance vanishes, and if p and p' both be zero the fault's distance vanishes, and there is no other case.

With regard to the first objection of loss of synchronism, it is well to observe that it can be entirely eliminated if the battery supplying the electromotive force E in the figure possess sufficiently low resistance. For it appears from the figure, and admits of easy proof, that the limit of the potential P when the battery resistance becomes indefinitely reduced is E (the difference of potential between the free poles), independently of the resistance of the rest of the circuit. In other words, P = E in the case we consider, whatever value be ascribed to $(\rho + x + f)$. Although this case is practically impossible, we can approximate to it with sufficient closeness to serve our purpose. For instance, suppose that we use 20 Thomson tray cells to obtain E. The resistance of these cells will be about 5 ohms in all. Suppose $\rho = x = f = 100$ ohms, then the total resistance of the circuit is 305 ohms, and in this case, an especially favourable one for revealing differences in the value of P, a variation in f of 100 per cent., namely, to zero or to 200 ohms, produces in the first case a reduction of P in the ratio of 1,000 : 992, and an increase of P in the second case in the ratio of 1,004 : 1,000. As it is practically seldom that $(\rho + x + f)$ is so low as 300 ohms, these differences in the value of P are much greater than are generally to be expected. The following correction can always, however, be applied when the greatest possible accuracy is required.

Let P_1 be the value of P when $(\rho + x + f)$ is known, and = R (advantageously an artificial resistance). Let p_1 be the corresponding value observed for p. Let r be the resistance of the battery. Then the value of P corresponding to any observed value p_2 of p, while ρ remains unaltered, is

$$P_2 = P_1 \times \frac{R\,(h\,p_1 - k p_2) + hk\,(p_2 - p_1)}{R\,\{h\,p_1 - k\,p_2 + k\,(p_2 - p_1)\}} \quad . \quad . \quad (II.)$$

where $h = R + r$, and $k = R - \rho$.

If then a low resistance battery be employed, it is only necessary to observe the potential at p during the test, and we can then observe P at leisure. The continuity of the readings is thus uninterrupted, and if taken at specified intervals at both stations may give comparative results of greater accuracy than would in the ordinary method have been effected.

It is needless to mention that the potentials p and p^1 are to "false zero," or to that potential as zero which the cable current produces when E = 0 or the battery removed from the circuit. This has already been shown in text books on the subject, and is easily proved.

We now come to the second weak point in the test. Even when p only is observed at Station A, P is also observed, although only as a constant. The formula shows that the fault's distance x is a direct function of these two potentials, and the third obtained at Station B. Practically it is a function of three deflections—galvanometric or electrometric—and these deflections are limited to some three or four hundred divisions on two-foot divided scales. The accuracy with which x can be calculated is primarily limited to these scale divisions, for although with a bright light, a good and clean mirror in the measuring instrument, and a very fine vertical wire in the path of light, deflections may occasionally be estimated to one-tenth of a division, yet some incertitude always exists in such close reading, even from the refraction of the plate glass before the instrument. Then, again, if Thomson galvanometers be used, the currents producing deflections being, strictly speaking, proportional to the tangents of half the deflection angles, correction must be introduced for this error.* Also the resistance of the fault itself is generally varying more or less throughout the test, and a corresponding change is produced in the potential deflections. These causes combine to render accurate reading uncertain and difficult, and the error which on this account alone may enter into the result is considerable. To take a simple case, suppose that the values in potential of a single division in deflection are equal for the instruments at A and B, and that

Deflection P at Station A was 301 divisions, but by reading error was noted as 300,

Deflection p at Station A was 199 divisions, but by reading error was noted as 200,

Deflection p' at Station A was 101 divisions, but by reading error was noted as 100,

Then from the accepted readings $x = \rho$;
but from the true deflections $x = \cdot957\,\rho$,
an error of more than 4 per cent.

Fig. 2, however, represents an arrangement in which part of the objection is overcome by the partial introduction of the Wheatstone bridge null method, and its greater accuracy in place of one potential deflection.

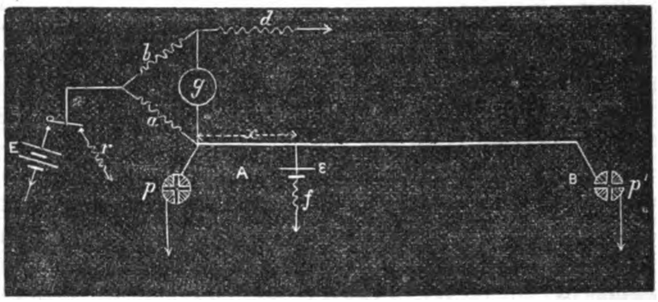

FIG. 2.

Formula (1) may be written

$$x = (x + f)\left(\frac{p - p'}{p}\right) \quad . \quad . \quad . \quad . \quad (III.)$$

where $$(x + f) = \frac{p\,\rho}{P - p} \quad . \quad . \quad . \quad . \quad . \quad (IV.)$$

Regarded in this light P serves to measure $(x + f)$.

This can be done with far more accuracy by the bridge, as shown. P is thus dispensed with, and

$$x = d\left(\frac{p - p'}{p}\right) \quad . \quad . \quad . \quad . \quad . \quad . \quad (V.)$$

when $a = b$.

p and p' are measured as before.

A can now make his deflection larger than before, and in that way increase the accuracy of his reading. To take the preceding example, $d = (x + f) = 1{\cdot}95\,\rho$, which we may suppose to be measured accurately. Now, suppose A adjusted p until it became twice as great as before. Suppose his true deflection to be 398 divisions, and that he read it as 399, while B's reading was 99, read as before 100. Then the apparent distance of the fault would be $\cdot9734\,\rho$, while the true distance would be $\cdot957\,\rho$, as before. The percentage of error has thus been reduced from 4 to $1\frac{1}{2}$.

The current at A is sent on depressing a key whose back contact is earthed through a resistance, r, equal to the internal resistance of the battery.

At first sight, it might be supposed that the electromotive force resident in the fault would not act upon the potential measurers at p and p' in quite the same manner when a bridge and divided circuit are employed, as in simple circuit only, but we shall now prove that this is not the case. Let $(x + f) = y$.

Then, by applying Kirchoff's laws in the usual way, and eliminating the successive currents, we find, calling c_5 the current passing through the galvanometer g,

$$c_5 = \frac{+\{E(by - ad)\} \pm \epsilon\{r(a+b) + a(b+d)\}}{g\{(a+y)(b+d) + r(a+b+d+y)\} + r\{(a+b)d + y)\} + bd(a+y) + ay(b+d)} \quad (VI.)$$

If now $\epsilon = 0$ the second compound term in the numerator of this fraction vanishes. If E = 0 the first vanishes. The current c_5 is therefore the sum, or difference, of two perfectly independent currents, and if we adjust our galvanometer zero to the deflection produced by the electromotive

* Vide Kempe's "Handbook of Electrical Testing," page 25.

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force ϵ, when the key is at rest, and we find no change in the deflection on introducing E, we know that the current whose numerator is the first term, and denominator, the whole denominator of the above fraction, is zero, so that $\frac{a}{b} = \frac{d}{y}$.

This proves that the galvanometer g can be read to false zero, which, of course, is universally admitted; we shall now in the same manner show that p and p' may be read to false zero.

Let c_4 be the current in the line or y.

Then

$$c_4 = \frac{E\{b(d+g)+d(a+g)\} \pm \epsilon\{b(d+g)+d(a+g)+ab+r(a+b+g)\}}{(r+y)\{b(d+g)+d(a+g)\}+a\{b(d+g)+g(d+r)\}+y\{ab+r(a+b+g)\}} \quad \text{(VII.)}$$

In this equation we see again that if $\epsilon = 0$ the second compound term in the numerator vanishes, and when $E = 0$ the first vanishes; so that c_4 is the sum or difference of two currents each independent of the other.

If p_m and p_n be the potentials at the extremities of any portion of y whose resistance is k, then by Ohm's law, if c_4 be the current flowing in y,

$$p_m - p_n = kc_4 \quad . \quad . \quad . \quad . \quad \text{(VIII.)}$$

Now let $E = 0$, and suppose that in consequence p_m, p_n, and c_4 become ϕ_m, ϕ_n, and c respectively,

Then $$\pm \phi_m \mp \phi_n = \pm kc. \quad . \quad . \quad . \quad . \quad \text{(IX.)}$$

Again, let $\epsilon = 0$, and suppose that in consequence p_m, p_n, and c_4 become Φ_m, Φ_n, and c respectively, then

$$\Phi_m - \Phi_n = kC \quad . \quad . \quad . \quad . \quad . \quad \text{(X.)}$$

Now let p_m, p_n, ϕ_m, ϕ_n, c_4, and c be all known, and let Φ_m and Φ_n be required. We have already seen that $c_4 = C \pm c$ from equation (VII.), and therefore

$$(p_m - p_n) = (\Phi_m - \Phi_n) \pm (\phi_m - \phi_n) \quad . \quad \text{(XI.)}$$

Therefore

$$\begin{aligned} \Phi_m - \Phi_n &= (p_m - p_n) \mp (\phi_m - \phi_n) \\ &= (p_m \mp \phi_n) - (p_n \mp \phi_n) \quad . \quad \text{(XII.)} \end{aligned}$$

From this we see that if the readings of p and p' are observed when the key at A is at rest, the potentials due to the electromotive force E are the sums or differences of these readings and those obtained when the key at A is depressed. In other words, the readings of p and p' are to "false zero."

To obtain still greater accuracy, those terminals of the potential measurers p and p', which are shown in the figure as directly connected to earth, may be respectively connected to sets of Varley slides or suitably arranged resistance through which currents of known strength flow to earth. Some point in this resistance is found at which the potential is the same as at p or p', both for the test reading and false zero. From these data the potentials can be directly deduced. Galvanometers may be employed if all the connections are well insulated and sharp contacts only made in their circuit until balance has been nearly obtained, otherwise the insulation of the points p and p' will be interfered with.

The test then becomes entirely a "null method." In practice it has yielded excellent results.

We may here remark that if the cable be long, and $(L - x)$ Fig. 1 several hundred miles, p' will have to be corrected for the loss by leakage through the dielectric. This correction is fully developed in Kempe's "Handbook," Chapter XXI., but for this bridge test the simplest formula is, perhaps,

$$\text{True } p' = (\text{Apparent } p') \frac{\left\{ e^{my}\left(\frac{Rm}{r}+1\right) + e^{-my}\left(\frac{Rm}{r}-1\right) \right\}}{\frac{2\,Rm}{r}} \quad \text{(XIII.)}$$

where $m = \sqrt{\frac{r}{i}}$

„ r = conductor resistance of unit length of cable,

„ i = dielectric resistance of unit length of cable,

„ y = approximate length in units of cable from B to the fault,

„ e = base of Naperian logarithms,

„ R = the resistance through which cable is to earth at B.

This formula applies more particularly to the case in which p' is measured by a galvanometer and high resistance. If, however, $R = \infty$, we have

$$\text{True } p' = (\text{Apparent } p') \frac{e^{my} + e^{-my}}{2} \quad . \quad . \quad \text{(XIV.)}$$

This is the formula given on page 286 of the above mentioned work.

We have hitherto considered the test as operative upon a single cable, but where a second and perfect cable is available to form a loop, there are one or two cases which it will be well to examine.

Whenever a loop test is available with a faulty cable, some modification of the Varley loop test is almost always adopted for localisation purposes. It were idle to deny the advantages which this form of the Wheatstone bridge possesses, its freedom from earth current, its sensitiveness, and its simplicity. For short cables it is doubtful if there be any other test to equal it in accuracy, but when the cables are long, and the temperature of the sea in which they are submerged comparatively high, the Varley balance cedes to the potential method in efficiency when the fault is near to the testing station. It is just in such cases that the Varley balance is most liable to error. Strict analysis shows, for one reason, that the ordinary correction for resultant fault is true only when the absolute insulation does not fall below a standard always reached in cables of great length. If the fault be near the centre of the loop the errors on each side tend to cancel each other, and to disappear, but the error on the contrary has almost its greatest effect when the fault is near the testing station. Another reason is that the metallic resistance of the loop which enters into the calculation for the fault's distance is not an exactly measurable quantity, and if it were, the correction to apply for loss by leakage is very complicated. In long cables this resistance of the loop, even though measured without the use of any earth at the testing station, is a function of the insulation of the cable, the resistance and position of the fault, and consequently it increases with the time the current has been applied. Polarisation generally interferes at the fault with the rate of increase in the observed readings, amd no tests taken while the cables are of normal insulation can entirely reproduce the conditions met with. In fact, the Varley loop test on long cables is, when fully developed, a very complicated inquiry.

Some advantage is gained, however, by not taking the resistance of the loop into account. It is only necessary to know the added resistance required to obtain balance, and the position by previous observations of the electrical centre in the loop; for when a resistance, R, has been added to one side of the faulty loop the position of the apparent fault is obviously $\frac{R}{2}$ ohms from the loop's centre on that side. This centre can be found while both cables are good by earthing the loop at the distant station, or, what is the same thing, putting both cables to earth there. A Varley balance then gives the added resistance needed to make the apparent cable-resistances equal, and after correction for leakage has been applied the loop's centre is directly found. This is always a more accurate result than any generally afforded by observed copper resistances of the cables separately, for obvious reasons. The apparent resistance of some long cables of good insulation differs from the resistances they would appear to have when the insulation would become infinite by as much as 150 ohms at the end of the first minute.

From these errors the potential test is free. The annual variation in resistance observed in long, shallow-water cables does not affect the electrical position of the fault determined by its aid. Provided the condition of the cable beyond the fault be homogeneous, or at least present some simple sequence, the effect of leakage can be very fairly eliminated, and *cœteris paribus* it is specially applicable to faults near the testing station, as the formula shows.

When a loop is available Fig. 3 represents, perhaps, the most sensitive arrangement of any that has been yet tried.

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The two galvanometers are balanced to false zero by the adjustment of $a\ b\ d\ b'$ and d'. Then we have

$$(x + f) = y = \frac{a d z}{b z - a d} \quad . \ . \ . \ . \ . \quad \text{(XV.)}$$

$$x = \frac{ob'd}{bz - ad} \quad . \ . \ . \ . \ . \quad \text{(XVI.)}$$

where $z = (b' + d')$. b' is corrected for leakage in $L - x$ by (XIV). The previous reasoning, as regards the correctness of reading g and g' to false zero, applies perfectly to this arrangement. If executed with care, and the insulation of all the apparatus be insured, the test is ordinarily very accurate.

We should endeavour to make g and g' as sensitive as possible. In practice their sensitiveness will be generally limited by the strength of the earth current. If this should interfere greatly, it is well to place a little shunted low-resistance battery in the direct line circuit, that is at the end of x, and by adjustment the electromotive forces may be made to cancel each other's effects. We may then promote the sensitiveness of the arrangement by suitably adjusting the resistances $a\ b\ b'\ d$ and d'.

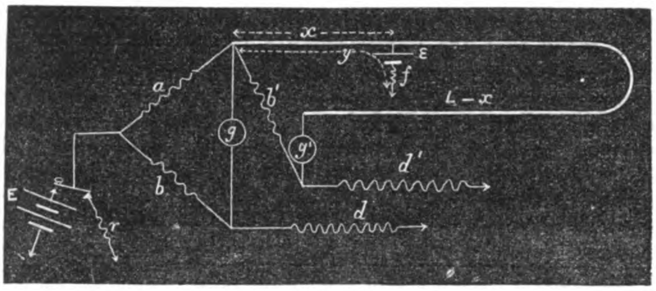

Fig. 3.

Into an examination of the best values for these resistances for any given value of y we need not enter. The subject is fully developed in "Kempe's Handbook," chapter VIII. We may, however, notice that it is specially advantageous to make $(b' + d')$ or z in the last equation as great as the sensitiveness of galvanometer g' will admit, for it is the object of the main bridge $a\ b\ g\ d$ to measure y, and if z be small not only will $\frac{y z}{y + z}$ be much less than y, but any change of resistance which may take place in y will be represented by only a small proportional change in d. In fact, if

$$\phi (y) = \frac{y z}{y + z}. \quad . \ . \ . \ . \quad \text{(XVII.)}$$

$$\phi' (y) = \frac{z^2}{(y + z)^2}. \quad . \ . \ . \quad \text{(XVIII.)}$$

and this fractional differential coefficient increases as z is increased, up to the limit unity, which we may express by saying that when $a = b$ and the currents in g and $g' = 0$, a single ohm's variation in y will produce a variation in d, increasing in amount from zero when $z = 0$ up to one ohm when z is infinite, x and f correspond to a' and x' respectively in Kempe's formulæ, and both are fixed quantities as regards the subsidiary bridge $x\ f\ b'\ d'\ g'$. To find in any case the best values for b' and d' from these formulæ we must remember that when the electromotive force at the fault may be neglected and the current in $g = 0$

$$r' = a + \frac{r (b + d)}{b + d + r}. \quad . \ . \ . \ . \quad \text{(XIX.)}$$

where r' is the resistance of the theoretical battery, and if $a = b$

$$E' = \frac{d E}{b + d + 2r} \times \frac{\lambda + r'}{\lambda}. \quad . \ . \quad \text{(XX.)}$$

where E' is the electromotive force of the theoretical battery, and λ is

$$\frac{y z}{y + z}.$$

Both these quantities are altered by altering the values of b' and d', so that the values required have to be obtained by successive approximation. Practically, Varley's slides answer well for $(b' + d')$, and with them z is always a constant quantity.

We may observe that there is an error with slides, which is readily made if care be not taken, and that is finding a slide reading at which balance is obtained with the earth current on g' while the battery key is at rest, and then taking a fresh reading to true zero when the key is depressed. It might at first sight be supposed that the difference of the two readings would measure the ratio of potentials p and p', but this is not the case, for when we balance to the earth current we merely observe the ratio of the potentials at p and at p' due to that earth current, and unless a special constant be taken there is no means of transmuting this reading to the ratios which the battery current gives. In fact, g and g' must be read strictly to false zero.

In conclusion, I have merely to observe that the forms of potential test described above have proved so useful to me, at times, too, when no other method tried yielded accurate results, that I am anxious that they may serve others equally well.—Yours, &c.,

A. E. Kennelly,
Electrician, Eastern Telegraph Company's
Suez, May, 1883. ss. "Chiltern," Suez.

THE GRAMME RING.

TO THE EDITOR OF THE ELECTRICIAN.

Sir: As the action of the Gramme ring is a question of much interest, I trust you will allow me to occupy some of your space by some further remarks with reference to Dr. Paget Higgs's second letter on the subject in your issue of the 26th May.

First, let me point out that the conclusions I ventured to question were (a) that gaps in the iron of the ring did not affect the "magnetic screen," and the inference that Antoine Breguet's screen theory was wrong; and (b) that "the inner wires were as efficacious as the outer wires." I did not argue that the inner wires were useless, as I think Breguet showed that they are of some service, although not nearly as useful as the other wires.

In his second letter Dr. Higgs allows that my suggested experiments are in favour of the supposition that the E.M.F. is due to the cutting of the lines of force by the wires; and that the number cut, and, consequently, the E.M.F. developed, is greatest in the case of the outer wires. But he discards this explanation in favour of one which, as I understand it, makes the presence of magnetic poles in the ring the cause of the E.M.F., the action being equal on inside and outside wires. He says:—"There are clearly two actions that may occur in the Gramme ring, (1) the constant approach and retrocession of an element of the ring into and from the magnetic field, (2) the cutting of the lines of force by the wires of the ring." I must confess that I find it very difficult to separate the effects of these actions from one another. Dr. Higgs contends that of these two causes of E.M.F., the second, in practice, may be neglected; and that "the greatest E.M.F. is undoubtedly due to (1), or the determination of the lines of force into the iron of the ring considered as a circular electro-magnet." Is not this rather contradictory? Dr. Higgs first says that "the cutting of the lines of force by the wires of the ring may be neglected," and then that "the determination of the lines of force into the iron of the ring is undoubtedly the greatest cause of E.M.F."

In producing E.M.F. we may, I suppose, take it that Faraday was right in teaching that magnetism acted by means of external lines of force, and, if this is the case, it is difficult to agree with Dr. Higgs that "the E.M.F. depends on the strength of the poles induced in the ring," rather than on the cutting of the lines of force; since the only action of the pole in the ring must be that due to its lines of force.

The experiment Dr. Higgs first describes to support his view—that of shortening the pole pieces—seems to me rather inconclusive. Does not the experiment point rather to a use-

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less passage of lines of force from pole to pole outside the ring? If the poles had been still longer at the commencement of the experiment the increase of E.M.F. would have been still greater; and if they had touched each other, or had been joined by a keeper, the E.M.F at starting would have been *nil*.

The second experiment of winding a ring drum fashion, and then ring fashion, rather favours my view than the reverse, as the E.M.F. was greater in the latter case than in the former. I should not have been prepared to find it "nearly twice as great," however; and as this expression is rather vague and the point is one of great interest, may I ask Dr. Higgs if he will kindly state what the increase really was?

To bear out his conclusion that the E.M.F. is the result of the poles in the ring, and is not caused by cutting the lines of force, as well as to show that inner and outer wires are equally efficacious, Dr. Higgs relates a third experiment, according to which a Schuckert ring, with poles on one side only, gave an E.M.F. only "2 to 3 per cent." below that obtained when it was moving between the usual four poles. This result was so extraordinary and so unexpected, affecting as it did the whole question of the construction of at least two well-known dynamo machines—the Schuckert and the Brush—that I repeated the experiment. My results differed very widely, however, from those of Dr. Higgs. Using the same external circuit in each case, separately exciting the field magnets, and maintaining a steady speed, I found that with four poles the product of current and E.M.F. in the external circuit was a little *more than* 100 *per cent. greater* than when two poles were employed; and this proportion was practically the same whether the field-magnets were saturated or not.—Yours, &c., W. M. Mordey.

May 30, 1883.

"DEAD TELEPHONES."—HOW DEAD TELEPHONES ARE MADE TO TALK IN THE UNITED STATES.

TO THE EDITOR OF THE ELECTRICIAN.

Sir: The Chicago *Inter Ocean* of April 22 finds evidence of the discovery of the telephone in 1865, as then published in the *Diritto* of Rome, July 10, also in *Echo d'Italia* of New York, U.S., August 19, 1865. The United States patent laws forbid the granting of patents on all discoveries that have been published in this or any foreign country. In the face of these facts the Patent Office has granted over 200 telephone patents since 1876, all based upon Signor Manzetti's claim of the "*transmission of the sound of the human voice by electricity*," as published in 1865. The American *Relay Telephone* claims discovery of *the transmission of sounds* by the earth's polarity, and that the electric currents magnetise or polarise the wire so as that sounds made at one end are heard instantly at the other. In telegraphy the polar circle around the wire is invisible.

But with three thousand times larger electric currents we get the polar light as now used in Haverley's Theatre. That without any of the popular "*vibratory or undulatory movements of electricity*" passes down and encircles the wire as quiet as molasses runs off of a straw.

Herein we find the polarity circle visible that when less intensive, acts in unison with the magnetic polar nerve tension, in creating the same sound instantly at both ends, when made at one end.

That man who discovered how to transfer the disturbing sounds of the human voice from one end of the magnet in a telephone in unison with the corresponding attraction and repulsion at the other end of the magnet, so as to harmonise at the polar centre of the line (which can only be accomplished by an adjustable device on the telephone, or in connection with the line, in order to fully comply with the undeviating law of polarity), must be the first man who discovered the telephone. This discovery was made by Henry C. Strong (a printer) at Galesburg, Illinois, in 1856, who published the polarity principle of the transmission of sounds in the *Peoria Statesman* in 1858. And he matured his discovery in the city of Chicago in 1876 by the use of a metallic diaphragm over one of Professor Morse's sounders. His discovery has been confirmed by patent from the United States on "The Relay Telephone," Dec. 21st, 1880. Chicago, therefore, has a just claim on prior discovery of the telephone against the world. And as within the last twenty years our country has engaged in creating wonderful reputations and then taking them away all along the line, it now remains with the United States Court to say which end of this telephone line. See *Official Gazette*, March 27, 1883; commissioners' decision—"Drawbaugh *v* Blake"—on the Bell transmitter. Then see April number, 17th. A patent issues to Drawbaugh as the prior discoverer of this transmitter, which is virtually only one end of a telephone. A. G. Bell obtained a patent in 1876, and one in 1877, both inoperative, for running both ends of a telephone (and remains so to this day), and by his infringement of Drawbaugh's end, in the Blake transmitter, he has managed to make a fortune out of both ends of the telephone in the United States.

Quite clever for John Bull!

Polar friction may, however, cause a little tremor in telephone stocks. Hedging is now in order.—Yours, &c.,

J. Barry Strong.

Barnes House, Chicago, May 21, 1883.

ELECTRIC LIGHT INQUIRY IN EDINBURGH.

TO THE EDITOR OF THE ELECTRICIAN.

Sir: Unless the public hear the other side of the question as regards the local inquiry in Edinburgh as to the want of the electric light there, a wrong impression may be conveyed by the paragraph in your journal as well as others.

It is stated that our advocate stated in opening that "he had not the benefit of the attendance of any of the responsible members of the company to help him."

Their attendance upon a local inquiry of the nature this inquiry was intended to be was not required. It was solely to ascertain whether the light was required, and this our agents were prepared to, and did, most conclusively prove; any other matter as to our position, financial or otherwise, we are quite prepared to prove before the Board of Trade. Had we received any intimation that the members of the Board of Trade intended to go over the ground traversed on the 11th and 15th May at Whitehall we should have prepared; but, having had none, it was simply our duty to prove, what had been stated before them on those two days, that the inhabitants of our compulsory area A wished to have the light, and this was done in a most satisfactory manner.

The matter will be brought before the Board again very probably, when, perhaps, they may see their way to alter their decision.—Yours, &c.,

Fred. M. Brockelbank, Secretary,
Brush Electric Light and Power Company of Scotland (Limited).

Dashwood House, New Broad-street, E.C., June 6, 1883.

THE SHADOW OF COMING EVENTS.

TO THE EDITOR OF THE ELECTRICIAN.

Sir: As an aspiring young electrician, I have read with great interest your account of the education and success of the eminent John Pender, Esq., M.P., who made a start in life hereabouts.

During the past winter I happened to be a student in drawing at the College of Science and Arts, Glasgow, where hanging on the wall I saw a picture bearing the following inscription:—"Design by John Pender, that gained in 1835-36 the gold medal given by Gavin Walker, Esq."

Coming events cast their shadows before.—Yours, &c.,

C. G. S.

THERMOPILES.

TO THE EDITOR OF THE ELECTRICIAN.

Sir: In answer to "C. D. S.," the proportions for the alloy in Clamond's thermopile are two parts antimony to one of zinc.—Yours, &c., Edgar Smart.

27, Victoria-grove, N.

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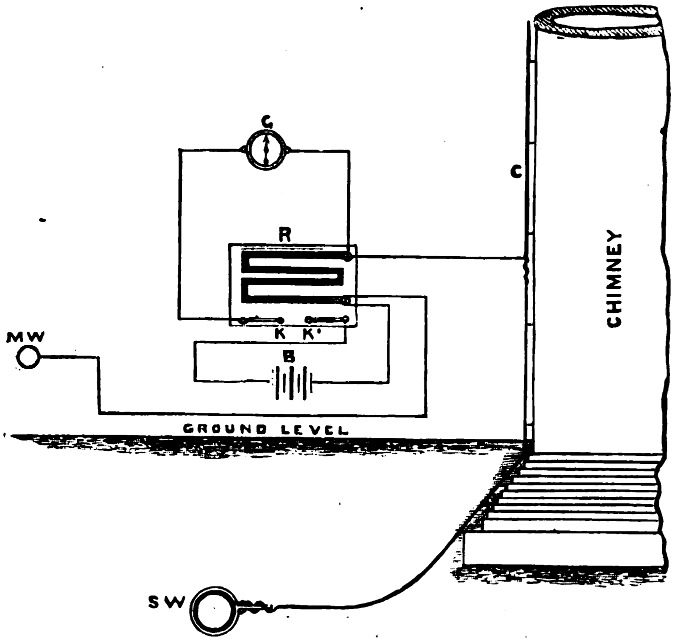
TESTING LIGHTNING CONDUCTORS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Replying to the letters in your issue for last week on the above subject, allow me to state in as few words as possible the conditions under which I made the tests communicated to you on the 22nd ult.

The instruments used were as follow, viz., a box of resistance coils with Wheatstone bridge, and a galvanometer having 10 ohms resistance with the current from three Leclanché cells. A No. 16 gutta percha insulated copper wire was twisted round the conductor as high up as possible, and carefully soldered thereto. This joint was made on No. 2 conductor, about 40ft. from the ground, while it was only 6ft. from the ground on No. 3. A good "earth" was got for the battery by soldering a No. 16 bare copper wire to the nearest lead water pipe, in connection with the main water system of the town. All being now ready, and the apparatus properly connected, the test for the "earth" of the conductor may be made in a few minutes without any assistance beyond that previously required to solder the wires to conductor and pipe.

The following diagram will illustrate the arrangement, and show the connections:—



G is the galvanometer, R the resistance coils and Wheatstone bridge, B the battery, C the conductor on the chimney, S W the "earth" of the conductor under test, consisting of a copper band clamped round a 15in. water pipe to the sea, with the lower end of the conductor threaded through small holes in a free end and soldered. M W the battery "earth"—a lead water pipe in connection with the main water supply.

On manipulating the keys K K' and the plugs in the box R the resistance of the conductor "earth" is easily ascertained in the manner described in the text books. The resistance is not constant; it varies considerably within certain limits. I have got in one day, at intervals of several minutes between the tests, the following results, viz., ·31, ·75, ·7, ·6, ·56, ·63, ·63, ·46, and ·56 ohm as that of "earth" resistance. This variation may also be due to polarisation of the battery, or other cause which I have not been able to determine.

I had an opportunity of testing the conductors by connecting a temporary wire to the spear, as was done at the Assembly Hall, Edinburgh, but I am inclined to think there is much less fear of bad joints in the conductor than of bad "earth." When an opportunity arises, however (which will be shortly in the case of one), I mean to have our conductors tested also. If the results turn out interesting, I may communicate them to you. Meantime, I hope some of your other correspondents will give your readers the benefit of their experience in this matter.—Yours, &c., T. L. P.

Greenock, 5th June, 1883.

P.S.—Please read *loose* for *hose* in the 16th line from the bottom of my letter of the 22nd ult.

A HISTORY OF ELECTRIC TELEGRAPHY TO THE YEAR 1837.

BY J. J. FAHIE, MEMB. SOC. TEL. ENGS. AND ELECS.*

(CONTINUED FROM PAGE 66.)

FRICTIONAL, OR STATIC, ELECTRICITY.

HISTORY IN RELATION TO THE ELECTRIC TELEGRAPH.

Thales' call,
He, whose enquiring mind paused musingly
On the mysterious power, to action roused
By amber rubbed. This power (to him) a spirit,
Woke from its slumbers by all-wondrous art.
—Oersted's "The Soul in Nature," p. 157 of Bohn's edition.

The science of electricity is a comparatively modern creation, dating only from the commencement of the seventeenth century. It owes nothing, or almost nothing, to antiquity, and, in this respect, forms a remarkable contrast to most of the other branches of human knowledge—notably those of astronomy and mechanics, heat and light. The vast discoveries, says Lardner,† which have accumulated respecting this extraordinary agent, by which its connection with, and influence upon, the whole material universe, its relations to the phenomena of organised bodies, the part it plays in the functions of animal and vegetable vitality, its subservience to the uses of man as a mechanical power, its intimate connection with the chemical constitution of material substances —in fine, its application in almost every division of the sciences, and every department of the arts, have been severally demonstrated, are exclusively and peculiarly due to the spirit of modern research, and, in a great degree, to the labours of the present age.

Yet it is not that, in this case, nature had concealed her secrets with more than her usual coyness, for we find, scattered through the writings of the ancients, many observations on a class of phenomena, which, if rightly examined, must have led to the establishment of electricity as a department of physics.

That amber acquires, by friction, the power of attracting light bodies, such as bits of straw, wood, and dry leaves, is a fact which is probably as old as the discovery of the substance itself. Thales, one of the seven wise men of Greece, described the property six hundred years before Christ, and not as if it were with him a new phenomenon, but rather as a familiar illustration of his philosophical tenets.‡ Aristotle, Pliny, and other Greek and Roman writers, also record the fact, and even sometimes mention luminous appearances attending the friction ("Plin," Book 37, chap. 3). Theophrastus, B.C. 321, on the authority of Diocles, speaks of the *lapis lyncurius*, supposed to be our modern tourmaline, as possessing the same property as amber, adding that it attracts not only straws and leaves, but copper also, and even iron, if it be in small particles ("De Lapidibus," p. 124, Hill's edition).

The emission of sparks from the human body, when submitted to friction, had also been noticed, as in the case of Servius Tullius, the sixth King of Rome, whose locks were frequently observed to give off sparks under the operations of the toilette. Eustathius, Bishop of Thessalonica A.D. 1160, cites another instance in his "Commentarii ad Homeri Iliadem," that of a certain ancient philosopher, who, occasionally, when changing his dress, emitted sparks, and, sometimes, even entire flames, accompanied by crackling noises. He also mentions the case of Walimer, a Gothic chief, who flourished A.D. 415, who used to give off sparks from his body.§ ("In Iliad." E, p. 515, Roman ed.)

* The author reserves all rights of translation.

† "Manual of Electricity, Magnetism, and Meteorology," Vol. I., p. 2.

‡ He ascribed to amber some living principle, some soul, which could be roused to action by friction, and, in the spirit of the age, it was declared sacred. For the same reason, the loadstone was venerated, it being supposed to possess an immaterial spirit under the influence of which it attracted iron. (Aristotle, "De Anima" I., 2.)

§ We do not notice the frequent allusions in the pages of Cæsar, Livy, Plutarch, and others, to flames at the points of the soldiers' javelins, at the tops of the masts of ships, and, sometimes, even on the heads of the sailors themselves; for all these phenomena, though now known to be of the same nature as those described in the text, were then regarded simply as manifestations of the Gods. See a very interesting example of this in Plutarch's "Life of Timoleon," Vol. III., p. 16, Dacier's edition. In the early ages of the Church, the Popes were often reckoned as magicians, Gregory VII. being held in especial awe, because when he pulled off his gloves fiery sparks issued from them.

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The Greeks and Romans were not the only people of antiquity to whom these phenomena were familiar. Thus, in the Persian language amber is called *Káh-rubá*, or, attractor of straw, as the magnet is called *Ahang-rubá*, or attractor of iron. In the old Persian romance, "The Loves of Majnoon and Leila," the lover says of his adored one, "She was as amber, and I but as straw; she touched me, and I shall ever cling to her." In the writings of Kuopho, a Chinese physicist of the fourth century, we read, "The attraction of a magnet for iron is like that of amber for the smallest grain of mustard seed. It is like a breath of wind, which mysteriously penetrates through both, and communicates itself with the rapidity of an arrow." Humboldt, after referring to this interesting fact, tells us how he himself had observed, with astonishment, on the woody banks of the Orinoco, in the sports of the natives, that the excitement of electricity by friction was known to these savage races. Children, he says, may be seen to rub the dry, flat, and shining seeds, or husks, of a trailing plant until they are able to attract threads of cotton and pieces of bamboo cane. ("Cosmos," London, 1849 ed., Vol. 1, p. 176.)

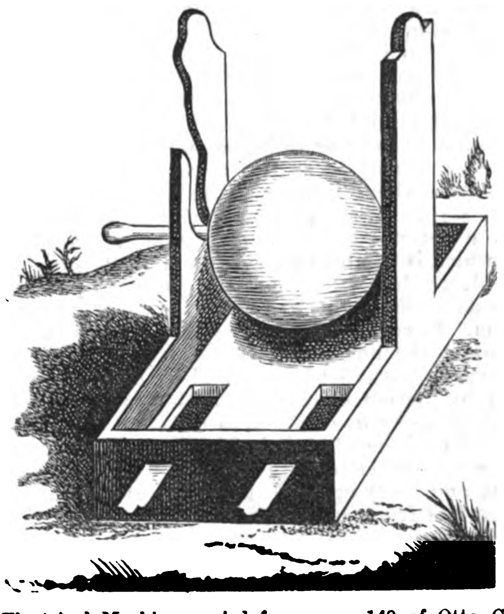
Such phenomena, says Lardner, in the work from which we lately quoted, attracted little attention, and provoked no scientific research. Vacant wonder was the most exalted sentiment they raised; and they accordingly remained, while centuries rolled away, barren and isolated facts upon the surface of human knowledge. The vein whence these precious fragments were detached, and which, as we have shown, *cropped out* sufficiently often to challenge the notice of the miner, continued unexplored; and its splendid treasures were thus reserved to reward the toil, and crown the enterprise, of modern times. (Vol. I., p. 4.)

Without going the length of asserting that electrical phenomena were entirely neglected during the long night of the middle ages, it seems certain that, with the exception of the discovery of the electrical property of jet, little advance was made up to the close of the sixteenth century. Then it was that Dr. Gilbert, of Colchester, for the first time collected the scattered fragments, and, with many valuable observations of his own, shaped them into the nucleus of a new science, to which he gave the name Electricity, from the Greek word ἤλεκτρον, signifying amber. In his great work, "De Magnete,"* published in the year 1600, he described the only three substances known up to his time as susceptible of electrical excitation, and added a variety of others, such as spars, jems, fossils, glasses, and resins, which enjoyed, equally with them, the power of attracting not only light bodies, like feathers and straws, but all solid and fluid matter, as metals, stones, water, and oil. He also observed some of the circumstances which affect the production of electricity, such as the hygrometric state of the atmosphere. Thus, he noticed that when the wind blew from the north and east, and was dry, the body could be excited by a brisk and light friction continued for a few minutes, but that when the wind was from the south and moist it was difficult, and sometimes impossible, to excite it at all. In order to test the condition of the various substances experimented upon, Gilbert made use of a light needle of any metal, balanced, and turning freely on a pivot, like the magnetic needle, to the extremities of which he presented the bodies after excitation. Some of Gilbert's deductions were curiously fallacious. In pointing out, for instance, the distinction between magnetic and electric attraction, he affirmed that magnets and iron mutually attracted each other, but that when an electric was excited it alone attracted, the substances attracted remaining inactive. He noticed also, as a special distinction between magnetism and electricity, that the former repelled as well as attracted, whilst the latter only attracted ("De Magnete," Lib. II., cap. II.—IV.).

The few references to electricity in the works of Sir Francis Bacon, Nicholas Cabeus, Kenelm Digby, Gassendi, Descartes, Thomas Browne, and others, may be passed over in silence, as they are chiefly theoretical, and did not contribute in any way to the advancement of the science.†

The celebrated Robert Boyle, to whom some of the other physical sciences owe such great obligations, directed much of his attention to the subject of electricity, and has left us an account of his experiments, in a small work, entitled "Experiments and Notes about the Mechanical Origine or Production of Electricity, London, 1675." By means of a suspended needle, he discovered that amber retained its attractive virtue after the friction which excited it had ceased; and though smoothness of surface had been regarded as advantageous for excitation, yet he found a diamond, which, in its rough state, exceeded all the polished ones, and all the electrics which he had tried, it having been able to move the needle three minutes after he had ceased to rub it. He found also that heat and "tersion" (*i.e.*, the cleaning or wiping of any body) increased the electrical effect; and that if the attracted body were fixed, and the attracting one movable, their approach would take place all the same, thus disproving one of Gilbert's deductions. To Dr. Gilbert's list of electrics, he added several new ones, as glass of antimony, white sapphire, white amethyst, carnelian, &c. Like all his predecessors, Boyle, in whom, by the way, the theorising faculty was particularly strong, speculated, in his turn, on the causes of electrical phenomena; but it seems that he, as well as they, could find no better explanation than that offered by the Ionic sage, twenty-three centuries before. The supposition was that the excited body threw out a glutinous, or unctuous, effluvium, which laid hold of small bodies in its path, and, on returning to its source, carried them along with it.* The *Philosophical Transactions* of this period contain some learned disquisitions in support of this (now strange) hypothesis, and even experiments are described which were considered as conclusive of its correctness (*Phil. Trans.* for 1699, Vol. 21, p. 5.)

Otto Guericke, burgomaster of Magdeburg, and inventor of the air pump, was contemporary with Boyle, and to him we owe some most important advances. In 1671, he constructed the first electrical machine, by means of which he was able to produce electricity in far greater quantities than had hitherto been possible from the friction of glass or sulphur rods. With this machine, which consisted of a globe of sulphur,† mounted on a revolving axis, and excited by the friction of a cloth held in the hand, he discovered the "hissing noise and gleaming light" which accompany strong electrification.



The First Electrical Machine, copied from page 148 of Otto Guericke's "Experimenta Nova," &c., by kind permission of Mr. Latimer Clark.

To him also belongs the discovery of the property of electrical repulsion. He ascertained that a feather, when attracted to an excited electric, was instantly repelled, and was incapable of a second attraction, until it had been touched by the finger or some other body. He also observed that a feather, when thus repelled, always kept the same side towards the excited electric—

* This book, although mainly devoted to magnetism, has many pages on Electricity; and, besides its intrinsic value, is interesting as containing the first publications on our subject. William Gilbert was a member of the College of Physicians, London, and became Physician in Ordinary to Queen Elizabeth, who, conceiving a high opinion of his learning, allowed him an annual pension to enable him to prosecute his studies. He died in 1603.

† Jacob Böhmen, the Teutonic theosopher, who lived 1575 to 1624, and who wrote largely on astrology, philosophy, chemistry, and divinity, has some pages devoted to electricity. See *Notes and Queries*, July 28, 1855, page 63.

* Boyle is sometimes said to have been the first, in modern times, to observe the electric light—an assertion which seems to be based upon his observation, in 1663, of the light which some diamonds gave out, in the dark, after being rubbed. But it is doubtful if this was not an optical, rather than an electrical effect, an instance of what may be called latent light, and, therefore, belonging to the class of phenomena, of which the celebrated Bologna stone, discovered in 1602 by the quondam shoemaker Casiorolus, was the first recorded example, as Balmain's luminous paint is the last. For much interesting information on this subject, see Sir D. Brewster's "Letters on Natural Magic."

† Sulphur, it may be remarked, was a favourite electric with early experimenters, as it was imagined that electricity was emitted with the sulphurous effluvium produced by the friction. In the construction of his machine, Guericke, for example, cast the sulphur in a glass globe, which he afterwards broke, so as to expose the sulphur to the action of the rubber, little imagining that the glass globe itself would have answered his purpose just as well.

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a fact the correspondence of which with the position of the moon towards the earth, induced him and other philosophers to assume that the revolution of the moon round the earth might be explained on electrical principles. Again, in the observation that a substance becomes electric by being merely brought near to another electrified body, Guericke discovered the fact, though not the principle, of induction ("Experimenta Nova Magdeburgica," Amstelodami, 1672, Lib. IV., cap. 15).

Newton, about the same time, published another effect of induction, viz.: one side of a glass plate being electrified, the other side will also be electrified, and will attract any light bodies within its influence. Laying upon a table a disc of glass two inches broad, in a brass hoop or ring, so that it might be one-eighth of an inch from the table, and then rubbing it briskly, little pieces of paper, laid upon the table under the glass, moved nimbly to and fro, and twirled about in the air, continuing these motions for a considerable time after he had ceased rubbing. Upon sliding his finger over the glass, though he did not agitate it nor, by consequence, the air beneath, he observed that the papers, as they hung under the glass, would receive some new motion, inclining this way or that, according to the direction of his finger. The Royal Society had ordered this experiment to be repeated at their meeting of December 16, 1675, and, in order to ensure its success, had obtained a full account of it from its distinguished author. The experiment, however, failed, and the secretary requested the loan of Sir Isaac's apparatus, inquiring, at the same time, whether or not he had guarded against the papers being disturbed by the air which might have somewhere stolen in? In replying, on the 21st of December, Newton advised them to rub the glass "with stuff whose threads may rake its surface, and if that will not do, rub it with the finger ends to and fro, and knock them as often upon the glass." Following these directions the society succeeded, on January 13, 1676, when they used a scrubbing brush of short hog's bristles, and the heft of a knife made with whalebone! (See Brewster's "Life of Sir Isaac Newton,;' pp. 307-8; or Birch's "History of the Royal Society," Vol. III., pp. 260-70).

In the 8th and 27th queries at the end of his treatise on "Optics," Newton has introduced the subject of electricity in such a manner as to convey some notion of the theoretical views which he had been led to form. He says (8th query):—"A globe of glass about 8 or 10 inches in diameter being put into a frame where it may be swiftly turned round, its axis will, in turning, shine where it rubs against the palm of one's hand applied to it; and if at the same time a piece of white paper be held at the distance of half an inch from the glass, the electric vapour, which is excited by the friction of the glass against the hand, will, by dashing against the paper, be put into such an agitation as to emit light, and make the paper appear livid, like a glowworm. In rushing out of the glass, it will even sometimes push against the finger so as to be felt." And again, in the 27th query, he says:—"Let him also tell me how an electric body can, by friction, emit an exhalation so rare and subtile, and yet so potent, as by its emission to cause no sensible diminution of the weight of the electric body, and to be expanded through a sphere whose diameter is above two feet, and yet to be able to agitate and carry up leaf copper, or leaf gold, at the distance of above a foot from the electric body."*

(TO BE CONTINUED.)

THE CAUSE OF EVIDENT MAGNETISM IN IRON, STEEL, AND OTHER MAGNETIC METALS.†

(CONCLUDED FROM PAGE 63.)

Neutrality.

The apparatus needed for researches upon evident external polarity requires no very great skill or thought, but simply an apparatus to measure correctly the force of the evident repulsion or attraction; in the case of neutrality, however, the external polarity disappears, and we consequently require special apparatus, together with the utmost care and reflection in its use.

From numerous researches previously made by means of the induction balance, the results of which I have already published, I felt convinced that, in investigating the cause of magnetism and neutrality, I should have in it the aid of the most powerful instrument of research ever brought to bear upon the molecular construction of iron, as indeed of all metals. It neglects all forces which do not produce a change in the molecular structure, and enables us to penetrate at once to the interior of a magnet or piece of iron, observing only its peculiar structure and the change which takes place during magnetisation or apparent neutrality.

The induction balance is affected by three distinct arrangements of molecular structure in iron and steel, by means of which we have apparent external neutrality.

Fig. 1. shows several polar directions of the molecules as indicated by the arrows. Poisson assumed, as a necessity of his theory, that a molecule is spherical, but Dr. Joule's experimental proof of the elongation of iron by $\frac{1}{720000}$ of its length when magnetised, proves at least that its form is not spherical; and, as I am unable at present to demonstrate my own views as to its exact form, I have simply indicated its polar direction by arrows, the dotted oval lines merely indicating its limits of free elastic rotation.

In Fig. 1, at A, we have neutrality by the mutual attraction of each pair of molecules, being the shortest path in which they could satisfy their mutual attractions. At B we have the case of superposed magnetism of equal external value, rendering the wire or rod apparently neutral, although a lower series of molecules are rotated in the opposite direction to the upper series, giving to the rod opposite and equal polarities. At C we have

Fig. 1.

the molecules arranged in a circular chain around the axis of a wire or rod through which an electric current has passed. At D we have the evident polarity induced by the earth's directive influence when a soft iron rod is held in the magnetic meridian. At E we have a longitudinal neutrality produced in the same rod when placed magnetic west, the polarity in the latter case being transversal.

In all these cases we have a perfectly symmetrical arrangement, and I have not yet found a single case in well-annealed soft iron in which I could detect a heterogeneous arrangement, as supposed by Ampère, De la Rive, Weber, Wiedermann, and Maxwell.

We can only study neutrality with perfectly soft Swedish iron. Hard iron and steel retain previous magnetisations, and an apparent external neutrality would, in most cases, be the superposition of one magnetism upon another of equal external force in the opposite direction, as shown at B, Fig. 1. Perfectly soft iron we can easily free, by vibrations, from the slightest trace of previous magnetism, and study the neutrality produced under varying conditions.

If we take a flat bar of soft iron, of 30 or more centimetres in length, and hold it vertically (giving, while thus held, a few torsions, vibrations, or, better still, a few slight blows with a wooden mallet, in order to allow its molecules to rotate with perfect freedom), we find its lower end to be of strong north polarity and its upper end south. On reversing the rod and repeating the vibrations we find that its lower end has precisely a similar north polarity. Thus the iron is homogeneous, and its polarity symmetrical. If we now magnetise this rod to produce a strong south pole at its lower portion, we can gradually reverse this polarity, by the influence of earth's magnetism, by slightly tapping the upper extremity with a small wooden mallet. If we observe this rod by means of a direction needle at all parts, and successively during its gradual passage from one polarity to the other, there will be no sudden break into a haphazard arrange-

* These appear to be the only published observations of the great Sir Isaac on electrical matters, but it would seem that, in moments of leisure from weightier business, he bestowed an occasional glance on the infant science. This will be apparent from the following extract from an autograph letter, which Mr. Latimer Clark has lately unearthed, and which will be found in full in *The Electrician* Journal for April 16, 1881:—"I have been much amused by ye singular φενομενα resulting from bringing of a needle into contact with a piece of amber or resin fricated on silke clothe. Ye flame putteth me in mind of sheet lightning on a small (how very small) scale." Although this letter is dated "London, December 15, 1716," it would seem from the wording that Newton was unaware of similar comparisons instituted, several years before, by Hauksbee and Wall.

† Paper read before the Society of Telegraph Engineers and of Electricians by Prof. D. E. Hughes, F.R.S., Vice-President, May 24, 1883.

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ment, but a gradual and perfectly symmetrical rotation from one direction to that of the opposite polarity.

If this rod is placed east and west, having first, say, a north polarity to the right, we can gradually discharge or rotate the molecules to zero, and as gradually reverse the polarity by simply inclining the rod so as to be slightly influenced by earth's magnetism; and at no portion of this passage from one polarity to neutrality, and to that of the opposite name, will there be found a break of continuity of rotation or haphazard arrangement. If we rotate this rod slowly, horizontally or vertically, taking observations at each few degrees of rotation of an entire revolution, we find still the same gradual symmetrical change of polarity, and that its symmetry is as complete at neutrality as in evident polarity.

In all these cases there is no complete neutrality, the longitudinal polarity simply becoming transversal when the rod is east and west. F, G, H, I, J, Fig. 1, show this gradual change, H being neutral longitudinally, but polarised transversely. If, in place of the rod, we take a small square soft iron plate and allow its molecules freedom under the sole influence of the earth's magnetism, then we invariably find the polarity in the direction of the magnetic dip, no matter in what position it be held, and a sphere of soft iron could only be polarised in a similar direction. Thus we can never obtain complete external neutrality whilst the molecules have freedom and do not form an internal closed circle of mutual attractions; and whatever theory we may adopt as to the cause of polarity in the molecule, such as Coulomb's, Poisson's, Ampère's, or Weber's, there can exist no haphazard arrangement in perfectly soft iron as long as it is free from all external causes except the influence of the earth; consequently these theories are wrong in one of their most essential parts.

We can, however, produce a closed circle of mutual attraction in iron and steel, producing complete neutrality as long as the structure is not destroyed by some stronger external directing influence.

Oersted discovered that an external magnetic needle places itself perpendicular to an electric current, and we should expect that, if the molecules of an iron wire possessed inherent polarity and could rotate, a similar effect would take place in the interior of the wire to that observed by Oersted. Wiedermann first remarked this effect, and it has been known as circular magnetism. This circle, however, consists really in each molecule having placed itself perpendicular to the current, simply obeying Oersted's law, and thus forming a complete circle, in which the mutual attractions of the molecules forming that circle are satisfied, as shown at C, Fig. 1. This wire becomes completely neutral, any previous symmetrical arrangement of polarity rotating to form its complete circle of attractions; and we can thus form in hard iron and steel a neutrality extremely difficult to break up or destroy. We have evident proof that this neutrality consists of a closed chain, or circle, as by torsion we can partially deflect them on either side, thus from a perfect externally neutral wire, producing either polarity, by simple mechanical angular displacement of the molecules, as by right or left-handed torsion.

If we magnetise a wire placed east and west, it will retain this polarity until freed by vibrations, as already remarked. If we pass an electric current through this magnetised wire, we can notice the gradual rotation of the molecules, and the formation of the circular neutrality. If we commence with a weak current, gradually increasing its strength, we can rotate them as slowly as may be desired. There is no sudden break or haphazard moment of neutrality; the movements to perfect zero are accomplished with perfect symmetry throughout.

We can produce a more perfect and shorter circle of attractions by the superposition of magnetism, as at B, Fig. 1. If we magnetise a piece of steel or iron in a given direction with a strong magnetic directing power, the magnetism penetrates to a certain depth. If we slightly diminish the magnetising power, and magnetise the rod in a contrary direction, we may reduce it to zero, by the superposition of an exterior magnetism upon one of a contrary name existing at a greater depth; and if we continue this operation, gradually diminishing the force at each reversal, we can easily superpose ten or more distinct symmetrical arrangements, and, as their mutual attractions are satisfied in a shorter circle than in that produced by electricity, it is extremely difficult to destroy this formation when once produced.

The induction balance affords also some reasons for believing that the molecules not only form a closed circle of attractions, as at B, but that they can mutually react upon each other, so as to close a circle of attractions as a double molecule, as shown at A. The experimental evidence, however, is not sufficient to dwell on this point, as the neutrality obtained by superposition is somewhat similar in its external effects.

We can produce a perfectly symmetrical closed circle of attractions of the nature of the neutrality of C (Fig. 1), by forming a steel wire into a closed circle, 10 centimetres in diameter, if this wire is well joined at its extremities by twisting and soldering. We can then magnetise this ring by slowly revolving it at the extremity of one pole of a strong permanent magnet; and, to avoid consequent poles at the part last touching the magnet, we should have a graduating wedge of wood, so that whilst revolving it may be gradually removed to greater distance. This wire will then contain no consequent points or external magnetism; it will be found perfectly neutral in all parts of its closed circle. Its neutrality is similar to C (Fig. 1); for if we cut this wire at any point we find extremely strong magnetic polarity, being magnetised by this method to saturation, and having retained (which it will indefinitely) its circle of attractions complete.

I have already shown that soft iron, when its molecules are allowed perfect freedom by vibration, invariably takes the polarity of the external directing influence, such as that of the earth, and it does so even with greater freedom under the influence of heat. Manufacturers of electro-magnets for telegraphic instruments are very careful to choose the softest iron and thoroughly anneal it; but very few recognise the importance as regards the position of the iron whilst annealing it under the earth's directing influence. The fact, however, has long since been observed.

Dr. Hooke, 1684, remarked that steel or iron was magnetised when heated to redness and placed in the magnetic meridian. I have slightly varied this experiment by heating to redness three similar steel bars, two of which had been previously magnetised to saturation, and placed separately with contrary polarity as regards each other, the third being neutral. Upon cooling, these three bars were found to have identical and similar polarity. Thus the molecules of this most rigid material, cast steel, had become free at red heat, and rotated under the earth's magnetic influence, giving exactly the same force on each; consequently the previous magnetisation of two of these bars had neither augmented nor weakened the inherent polarity of their molecules. Soft iron gave under these conditions by far the greatest force, its inherent polarity being greater than that of steel.

I have made numerous other experiments bearing upon the question of neutrality, but they all confirm those I have cited, which I consider afford ample evidence of the symmetrical arrangement of neutrality.

Superposed Magnetism.

Knowing that by torsion we can rotate or diminish magnetism, I was anxious to obtain by its means a complete rotation from north polarity to neutrality, and from neutrality to south polarity, or to completely reverse magnetic polarity by a slight right or left torsion.

I have succeeded in doing this, and in obtaining strong reversal of polarities, by superposing one polarity given whilst the rod is under a right elastic torsion, with another of the opposite polarity given under a left elastic torsion, the neutral point then being reached when the rod is free from torsion. The rod should be very strongly magnetised under its first or right-hand torsion, so that its interior molecules are rotated, or, in other words, magnetised to saturation; the second magnetisation in the contrary sense and torsion should be feebler, so as only to magnetise the surface, or not more than one-half its depth. These can be easily adjusted to each other so as to form a complete polar balance of force, producing when the rod is free from torsion, the neutrality as shown at B, Fig 1.

The apparatus needed is simply a good compound horse-shoe permanent magnet, 15 centimetres long, having six or more plates, giving it a total thickness of at least 3 centimetres. We need a sufficiently powerful magnet, as I find that I obtain a more equal distribution of magnetism upon a rod or strip of iron by drawing it lengthwise over a single pole in a direction from that pole, as shown in Fig. 2; we can then obtain saturation by repeated drawings, keeping the same molecular symmetry in each experiment.

In order to apply a slight electric torsion when magnetising rods or wires, I have found it convenient to attach two brass clamp keys to the extremities of the rods, or simply turn the ends at right angles, as shown in the following diagram, by which means we can apply an elastic twist or torsion whilst drawing the rod over the pole of the permanent magnet. We can thus superpose several and opposite symmetrical structures, producing a polar north or south, as desired, greatly in excess of that possible under a single or even double magnetisation, and by carefully adjusting the proportion of opposing magnetisms, so that both polarities have the same external force, the rod will be at perfect external neutrality when free from torsion.

If we now hold one end of this rod at a few centimetres distance from a magnetic directive needle, we find it perfectly neutral when free of torsion, but the slightest torsion right or left at once produces violent repulsion or attraction, according to the direction of the torsion given to the rod, the iron rod or strips of

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hoop iron which I use for this experiment being able, when at the distance of five centimetres from the needle, to turn it instantly 90deg. on either side of its zero.

The external neutrality that we can now produce at will is absolute, as it crosses the line of two contrary polarities, being similar to the zero of my electric sonometer, whose zero is obtained by the crossing of two opposing electric forces.

This rod of iron retains its peculiar powers of reversal in a remarkable degree, a condition quite different to that of ordinary magnetisation, for the same rod, when magnetised to saturation under a single ordinary magnetism, loses its evident magnetism by a few elastic torsions, as I have already shown; but when it is magnetised under the double torsion with its superposed magnetism, it is but slightly reduced by variations or numerous torsions, and I have found it impossible to render this rod again free from its double polar effects, except by strongly re-magnetising it to saturation with a single polarity. The superposed magnetism then becomes a single directive force, and we can then by a few vibrations or torsions reduce the rod to its ordinary condition.

The effects of superposed magnetism and its double polarity I have produced in a variety of ways, such as by the electro-magnetic influence of coils, or in very soft iron simply by the directive influence of the earth's magnetism, reversing the rod and torsions when held in the magnetic meridian, these rods when placed magnetic west showing distinctly the double polar effects.

It is remarkable, also, that we are enabled to superpose and obtain the maximum effects on thin strips of iron from ¼ to ½ millimetre in thickness, whilst in thicker rods we have far less effect, being masked by the comparatively neutral state of the interior, the exterior molecules then reacting upon those of the interior, allowing them to complete in the interior their circle of attractions.

I was anxious to obtain wires which would preserve this structure against the destructive influence of torsion and vibrations, so that I could constantly employ the same wires without

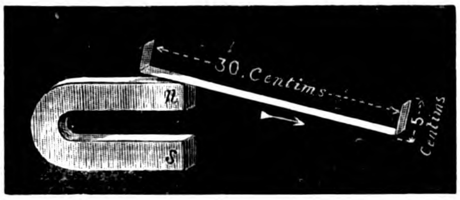

Fig. 2.

the comparatively long and tedious process of preparation. Soft iron soon loses the structure, or becomes enfeebled, under the constant to and fro torsions requisite where we desire a constant change of polarity, as described later in the magnetic bells. Hard steel preserves its structure, but its molecular rigidity is so great that we obtain but mere traces of any change of polarity by torsion. I have found, however, that fine cast drill steel, untempered, of the kind employed by watchmakers, is most suitable; these are generally sold in straight lengths of 30 centimetres. Wires 1 millimetre in diameter should be used, and when it is desired to increase the force, several of these wires, say nine or ten, should be formed into a single rod or bunch.

The wire as sold is too rigid to give its maximum of molecular rotation effect. We must therefore give it two entire turns or twists to the right, and strongly magnetise it on the north pole of the magnet whilst under torsion. We must again repeat this operation in the contrary direction, after restoring the wire to its previous position, giving now two entire turns to the left and magnetising it on the south pole. On restoring the wire to its original place, it will be extremely flexible, and we may now superpose several contrary polarites under contrary torsions, as already described.

The power of these wires, if properly prepared, is most remarkable, being able to reverse their polarity under torsion, as if they were completely saturated; and they preserve this power indefinitely if not touched by a magnet. It would be extremely difficult to explain the action of the rotative effects obtained in these wires under any other theory than that which I have advanced; and the absolute external neutrality that we obtain in them when the polarities are changing, we know, from their structure, to be perfectly symmetrical.

I was anxious to show, upon the reading of this paper, some mechanical movement produced by molecular rotation, consequently I have arranged two bells that are struck alternately by a polarised armature put in motion by the double polarised rod I have already described, but whose position, at three centimetres distant from the axis of the armature, remains invariably the same. The magnetic armature consists of a horizontal light steel bar suspended by its central axle; the bells are thin wine glasses, giving a clear musical tone loud enough, by the force with which they are struck, to be clearly heard at some distance. The armature does not strike these alternately by a pendulous movement, as we may easily strike only one continuously, the friction and inertia of the armature causing its movements to be perfectly dead-beat when not driven by some external force, and it is kept in its zero position by a strong directive magnet placed beneath its axle.

The mechanical power obtained is extremely evident, and is sufficient to put the sluggish armature in rapid motion, striking the bells six times per second, and with a power sufficient to produce tones loud enough to be clearly heard in all parts of the hall of the society. As this is the first direct transformation of molecular motion into mechanical movement, I am happy to show it on this occasion.

There is nothing remarkable in the bells themselves, as they evidently could be rung if the armature was surrounded by a coil, and worked by an electric current from a few cells. The marvel, however, is in the small steel superposed magnetic wire producing by slight elastic torsions from a single wire, 1mm. in diameter, sufficient force from mere molecular rotation to entirely replace the coil and electric current.

Elastic Nature of the Ether Surrounding the Magnetic Molecules.

During these researches I have remarked a peculiar property of magnetism, viz., that not only can the molecules be rotated through any degree of arc to its maximum, or saturation, but that, whilst it requires a comparatively strong force to overcome its rigidity or resistance to rotation, it has a small field of its own through which it can move with excessive freedom trembling, vibrating, or rotating through a small degree with infinitely less force than would be required to rotate it permanently on either side. This property is so marked and general that we can observe it without any special iron or apparatus.

Let us take a flat rod of ordinary hoop-iron, 30 or more centimetres in length. If, whilst holding this vertically, we give freedom to its molecules by torsions, vibrations, or, better still, by a few blows with a wooden mallet upon its upper extremity, we find, as is well known, that its lower portion is strongly north, and its upper south. If we reverse this rod, we now find it neutral at both extremities. We might here suppose that the earth's directing force had rotated the molecules to zero or transversely, which in reality it has done, but only to the limit of their comparatively free motion; for, if we reverse the rod to its original position, its previous strong polarity reappears at both extremities, thus the central point of its free motion is inclined to the rod, giving by its free motion great symmetrical inclination and polarity in one direction, but when reversed the inclination is reduced to zero.

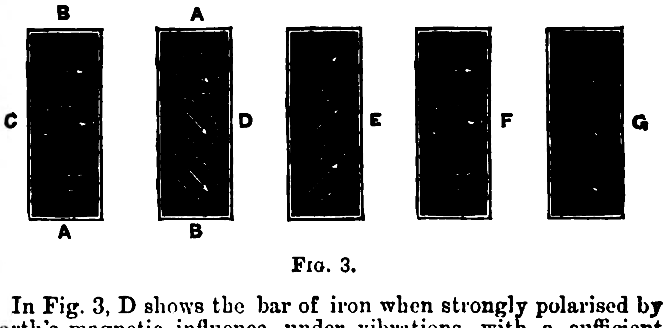

Fig. 3.

In Fig. 3, D shows the bar of iron when strongly polarised by earth's magnetic influence, under vibrations, with a sufficient force to have rotated its elastic centre of action. C shows the same bar with its molecules at zero, or transversal, the directing force of earth being insufficient without the aid of mechanical vibration to allow them to change. The dotted lines of D suppose the molecule to be in the centre of its free motion, whilst at C the molecules have rotated to zero, as they are prevented from further rotation by being at the extreme end of its free motion.

If, now, we hold the rod vertically, as at C, giving neutrality, and give a few slight blows with a wooden mallet to its upper extremity, we can give just the amount of freedom required for it to produce evident polarity, and we then have equal polarity, no matter which end of the bar is below, the centre of its free rotation here being perfect, and the rod perfectly neutral longitudinally when held east and west. If, on the other hand, we have given too much freedom by repeated blows of the mallet, its centre of free motion becomes inclined with the molecules, and we arrive at its first condition, except that it is now neutral at

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D, and polarised at C. From this it will be seen that we can adjust the centre of action, by vibrations or blows, to any point within the external directing influence.

We can perceive this effect of free rotation in a limited space in all classes of iron and steel, being far greater in soft Swedish iron than in hard iron or steel. A similar phenomenon takes place if we magnetise a rod held vertically in the direction of earth's magnetism. It then gives greater polarity than if magnetised east or west, and if magnetised in a contrary sense to earth's magnetism, it is very feebly magnetised, or, if the rod is perfectly soft, it becomes neutral after strong magnetisation. This property of comparative freedom, and the rotation of its centre of action, can be demonstrated in a variety of ways. One remarkable example of it consists in the telephone. All those who are thoroughly acquainted with electro-magnetism, and know that it requires measurable time to charge an electro-magnet to saturation (about $\frac{1}{15}$ of a second for those employed in telegraphy), were surprised that the telephone could follow the slightest change of timbre, requiring almost innumerable changes of force per second. I believe the free rotation I have spoken of through a limited range explains its remarkable sensitiveness and rapidity of action, and, according to this view, it would also explain why loud sounding telephones can never repeat all the delicacy of timbre that is easily done with those only requiring a force comprised in the critical limits of its free rotation. This property, I have found, has a distinct critical value for each class of iron, and I propose soon to publish researches upon the molecular construction of steel and iron, in which I have made use of this very property as a guide to the quality of the iron itself.

The elastic rotation (in a limited space) of a molecule differs entirely from that known as mechanical elasticity. In perfectly soft iron we have feeble *mechanical* elasticity, whilst in tempered steel we have that elasticity at its maximum. The contrary takes place as regards *molecular* elasticity. In tempered steel the molecules are extremely rigid, and in soft iron its molecular elasticity is at its maximum. Its free motion differs entirely from that given it by torsion or stress. We may assume that a molecule is surrounded by continuous ether, more of the nature of a jelly than of that of a gas; in such a medium a molecule might freely vibrate through small arcs, but a rotation extending beyond its critical limit would involve a much greater expenditure of force.

The discovery of this comparatively free rotation of molecules, by means of which, as I have shown, we can (without in any degree disturbing the external mechanical elasticity of the mass) change the axes of their free motion in any direction desired, has led me into a series of researches which have only indirectly any relation with the theory of magnetism. I was extremely desirous, however, of finding an experimental evidence which in itself should demonstrate all portions of the theory, and the following experiment, I believe, answers this purpose:—

Let us take a square soft iron rod, 5 millimetres in diameter by 30 or more centimetres in length, and force the molecules, by aid of blows from a wooden mallet, as previously described, to have their centres of free motion in one direction, the rod will (as already shown) have polarity at both ends, when held vertically; but, if reversed, both ends become completely neutral.

If now we turn the rod to its first position, in which it shows strong polarity, and magnetise it whilst held vertically, by drawing the north pole of a sufficiently powerful permanent magnet from its upper to its lower extremity, we find that this rod, instead of having south polarity at its lower portion, as we should expect from the direction of the magnetisation, is completely neutral at both extremities, but if we reverse the rod, its fullest free powers of magnetisation now appear in the position where it was previously neutral. Thus, by magnetisation, we have completely rotated its free path of action, and find that we can rotate this path as desired in any direction by the application of a sufficient directing power.

If we take a rod as described, with its polarities evident when held vertically, and its neutrality also evident when its ends are reversed in the same magnetic field, we find that its polarity is equal at both ends, and that it is in every way symmetrical with a perfect magnet. If we *gradually* reverse the ends and take observations of its condition through each degree of arc passed over, we find an equal symmetrical diminution of evident external polarity until we arrive at neutrality, when it has no external trace of inherent polarity, but its inherent polarity at once becomes evident by a simple return to its former position. Thus the rod has passed through all the changes from polarity to neutrality, and from neutrality to polarity, and these changes have taken place with complete symmetry.

The limits of this paper do not allow me to speak of the numerous theoretical evidences as shown by the use of my induction balance. I believe, however, that I have cited already experimental evidences to show that what has been attributed to coercive force is really due to molecular freedom or rigidity; that in inherent molecular polarity we have a fact admitted by Coulomb, Poisson, Ampère, De la Rive, Weber, Du Moncel, Wiedermann, and Maxwell; and that we have also experimental evidence of molecular rotation and of the symmetrical character of polarity and neutrality.

The experiments which I have brought forward in this paper, in addition to those mentioned in my paper read before the Royal Society, will, I hope, justify me in having advanced a theory of magnetism which I believe in every portion allows at least experimental evidences of its probable truth.

ON INCANDESCENT LIGHTING.*

BY WILLIAM SIEMENS.

The words incandescent light have no thoroughly precise meaning, and there are lighting arrangements passing under this name which have nothing whatever to do with the subject of my paper. I shall only treat of those incandescent lights which actually consist of a glowing carbon filament at a white heat in a vacuum.

Carbon is a conductor of the electric current, and is heated by the passage of the same. This heating of the carbon can reach a certain white glow by strengthening the current without injury to it. When this degree of heating is reached and remains constant, a continuous flowing of the current in the unit of time is necessary, to which then a fixed radiation in the same period corresponds. The power, which is expended by the current on the carbon, is represented as $E\,C = \frac{E^2}{R} = C^2\,R$, where E represents the difference of potential measured at the two ends of the carbon filament, C the actual strength of the current, and R the resistance of the carbon. The corresponding light given out by this power with a fixed heating is proportional to the extent of the surface of the carbon. Let l be the length of the carbon and d its circumference (in which case the section is taken as a circle), then the surface $= l\,d$. For the equilibrium between current = work and radiation the relation stands thus (leaving out the constants and assuming identical heating and identical materials), $E\,C = l\,d$.

It is clear that under the limitations above mentioned the product $l\,d$ also furnishes a measure for that part of the total radiation which presents itself in the form of lighting heat rays or light, in contradistinction to the dark and chemical heat rays.

Thus to a fixed quantity of light or to a fixed total of light rays corresponds a definite extent of the surface of the carbon and a definite work performed by the current. The performance of this work remains unaltered, though both the factors of the product E C be varied in such a way that the product itself remains constant. The larger E the smaller will C be. Thus for the same performance of work correspond currents of the most varied character, small currents of high E.M.F. and large currents of low E.M.F. Therefore, the resistance R also varies consistently with the $= \frac{E^2}{R} = C^2\,R =$ constant.

From $E\,C = l\,d =$ constant it follows $\frac{E}{l} = \frac{d}{C}$, from which it is to be seen that corresponding to the variation of E and C also the factors l and d of the constant product $l\,d$ vary.

One is therefore in a position for the production of light of a given strength, which (assuming identical temperature and identical materials) corresponds to a definite surface, to use carbons of the most diverse shapes. Incandescent lights are thus distinguished according to the form of their carbon filaments. The lamps with long, thin filaments would require correspondingly high E.M.F., whilst the short, thick filaments require a larger current and lower E.M.F.

As a type of the high tension lamps I may mention the Edison lamp, as a type of lamps requiring greater current the Swan lamp. A characteristic difference, however, lies in the difference of the sectional area, decreasing with increasing E.M.F. A great advantage is certainly connected with the larger diameter (supposing the other conditions to be constant), to wit a greater solidity of the carbon and a longer duration.

The durability of the carbon is exposed to a series of more or less injurious influences, which in the majority of cases prove the more detrimental the smaller the filament. In this respect the purely mechanical effects of the blows and shakings to which the lamps are subjected, particularly in transit, are by no means to be underrated.

According to the mechanical gas theory the last little remains

* Translated from the *Electrotechnische Zeitschrift*, March, 1883.

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of air, which even after the application of the best air pumps remain in the lamp globe in consequence of the great heating of the carbon, are found to be in very quick movement, and the filament is therefore exposed in a certain measure to a constant bombardment, to which it will offer the longer resistance the larger its sectional area.

An observation of Edison's comes in here. It is to the effect that one side of the carbon filament, though an equally directed current goes through it, is more quickly consumed than the other. In order to account for this one must imagine a kind of electrolytic process to take place. The space in the globe, therefore, is not to be considered as an absolute vacuum, but as containing air in a very highly alternated condition. In the event of this being really the case, further support is given to the contention that a thick filament lasts longer than a thin one. In addition, it is generally accepted that the electric current exercises an influence on the molecular structure of the carbon. It is observed, for instance, that copper wires which have been used for a longer time in an alternating current machine assume a different character, molecularly, from that which they possessed previous to such use.

The greater heating to which the carbon filament is exposed, so much the worse for its durability, and the above-named injurious influences are the more perceptible and make themselves especially felt in the case of the thin carbon filaments. In general a thick carbon filament will bear a greater heating than a thin one—which is of importance, not only on economical grounds, but also on æsthetical, as a greater whiteness of the light corresponds to a higher temperature.

To this advantage possessed by the lamps requiring greater current (which as I will show later on applies in a certain sense also to lamps requiring high E.M.F.) there are, however, on the other hand, greater disadvantages, and these particularly lie in costliness of the "leads." The greater C in C E the greater is the quantity of copper required.

On account of security against danger from fire, the "leads" must be so chosen that their heating through the current used in the installation does not exceed a certain measure. Respecting the proportion between strength of current and strength of wire assuming constant heating, there are three views entertained, viz: $C = d$, $C = d^2$, $C = \sqrt{d^3}$ ($d =$ diameter of the wire). The constants are, of course, here left out. In practice the second view is preferably adopted, although neither the calculations nor the results of any experiments instituted respecting this proportion agree. The question is here of bare stretched wire, and the assumption is made that no loss of heat takes place through conduction. The case is otherwise if the wire is coiled. For two coils of equal size and weight, which are covered with wire of different thickness, according to Forbes the equation is: $C = d^2$. Let C and C' stand for the strength of the current, and R and R' the resistances of the coils. Then the quantities of heat produced are $= C^2 R$ and $C'^2 R'$. As the surfaces of the two coils are equal, and the heating should be the same, the radiations must also be equal. Therefore, $C^2 R = C'^2 R'$, or $\frac{C^2}{C'^2} = \frac{R'}{R} = \frac{d^4}{d'^4}$, or $\frac{C}{C'} = \frac{d^2}{d'^2}$.

Some writers give the relation $C = \sqrt{d^3}$ as theoretically correct. It is, however, at the same time remarked that the result of experiments (as for instance those of Zollner and Forbes) does not agree with this formula, but rather with $C = d$. The equation $C = \sqrt{d^3}$ is obtained in the following manner:—$E\,C = l\,d$; $C^2 R = l\,d$; $\frac{C^2 R_s}{d^2} = d$; $C^2 R_s = d^3$. If the specific resistance $R_s = 1$, then $C = \sqrt{d^3}$.

This equation is throughout correctly deduced, but more might be considered to be in it than does lie in it, if one were to deduce therefrom that C according to the relation $C = \sqrt{d^3}$ changes with d. For, in fact, in doing so, the actual condition contained in the problem would not be taken into account, that the heating or temperature of the wire should not change by the variation of C, which amounts to this, that the radiation corresponding to a fixed extent of surface (to the unit of area for example) remains constant; or $l_1\,d_1 =$ const.; if l_1 and d_1 indicate the dimensions of this part of the surface.

This condition cannot, however, be made to accord with $C = \sqrt{d^3}$, as here no length l occurs, which is the reason why the same is not applicable here.

As already mentioned, the relation $C = d$ is confirmed by experiments. Its correctness can thus be made apparent.

$$C\,E = K\,l\,d,$$
$$C = K_1\,d,$$
$$E = K_2\,l;$$

the multiplication of these last two equations gives the first. $K\,K_1$ and K_2 are constants.

In case the conductor has any other, for instance a rectangular section, the relation generally runs: $u = C$, u representing the circumference. The quantity of copper measure in the conductor depends on the sectional area. In order to save copper, we may arrange that the sectional area for a given surface is the smallest possible. A rectangular section is therefore better than a circular one, and it is more advantageous for the "lead" to consist of several parallel thin wires than of one thick one.

The relation $d = C$ shows how comparatively unfavourable lamps requiring greater current are, as double current necessitates four times the quantity of wire.

To the result $C = d$ or $C = u$ we are brought by another consideration. In an incandescent lamp installation the conductors will consume a certain portion of the strength of the current. The resistance of the conductors should therefore be as small as possible, so that the loss in power should be a minimum. Practice allows the conductors about 10 per cent. of the power used in working the lamps, and as a consequence the resistance of the conductors amounts to 10 per cent. of the resistance of the lamps.

For lamps having the same illuminating power, temperature, and materials, the resistances are in inverse ratio to the squares of the corresponding strengths of current (follows from $C_2\,R_s =$ constant.) Thus, according to the selection of lamps requiring double or threefold strength of current, the corresponding resistance of the conductor amounts to the fourth or ninth.

(TO BE CONTINUED.)

COMPANIES' SHARE LIST.

TELEGRAPHS.

Companies.	Closing Prices June 6.		Business Done Week Ending June 6. Highest.	Lowest.
Anglo American	50,	51	50¾	50½
Do. Preferred	82,	83	83	82½
Do. Deferred	20,	21	20¾	20½
Brazil Submarine	11¾,	12	11¾	11½
Cuba	10,	10½	10¾	10½
Do. Preference	17,	18	—	—
Direct Spanish	5½,	6	—	—
Do. Preference	16,	16½	16¼	16 1-16
Direct United States Cable	12¼,	12¾	12¾	12½
Eastern Telegraph	10¾,	11	10 15-16	10¾
Do. 6 per Cent. Preference	13,	13½	13½	13½
Do. 5 per Cent. Debentures, 1899	104,	107	—	—
Eastern Extension	12,	12½	12 3-16	12
German Union	9¾,	10½	10	10
Globe Telegraph and Trust Company	7,	7¼	7¾	7
Do. Preference	12¾,	13¼	13	12¾
Great Northern	12¾,	13	13½	12¾
Indo-European	31½,	32½	32	32
Mediterranean Extension	1½,	2	—	—
Do. Preference	6,	7	—	—
Reuter's	9½,	10	9 13-16	9½
Submarine	247,	252	—	—
West India and Panama	1½,	1¾	1 3-16	1½
Do. 1st Preference	6½,	7	—	—
Western Brazilian	6½,	6¾	6 11-16	6¾
West. Union 7 per Cent. 1st Mortgage	122,	124	—	—
Do. 6 per Cent. Sterling Bonds	103,	106	—	—

TELEPHONES.

Companies.	Closing Prices June 6.		Highest.	Lowest.
Consol. Telephone and Maintenance	¾,	⅞	⅞	¾
Oriental	¾,	⅞	¾	¾
United Telephone	9½,	10	9¾	9½

ELECTRIC LIGHT.

Companies.	Closing Prices June 6.		Highest.	Lowest.
Anglo-American Brush Lgt. (£7 paid).	3¾,	4½	4½	3¾
Do. (fully paid)	6½,	7½	7½	7
Hammond Light	2½,	3	2¾	2½
Pilsen, Joel, and General Electric	½,	¾	—	—
Swan	1½,	1¾	1¾	1¾
Maxim-Weston	½,	¾	—	—

TRAFFIC RECEIPTS FOR MAY, 1883.

Companies.	May, 1883.	May, 1882.	Incrse.	Decrs.
Anglo-American Telegraph Company	—	—	—	—
Brazilian Submarine Company	—	—	—	—
Cuba Submarine Company	3,300	3,544	—	244
Direct United States Cable Company	—	—	—	—
Direct Spanish Telegraph Company	1,638	1,038	600	—
Eastern Telegraph Company	—	—	—	—
Eastern Extension Telegraph Company	32,156	33,087	—	931
Great Northern Telegraph Company	22,600	—	—	—
Submarine Telegraph Company	—	—	—	—
West Coast of America Telegraph Company	—	—	—	—
Western and Brazilian Telegraph Company	—	—	—	—

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NOTES.

Electric Lighting in Australia.—It is stated that steps are being taken to form an electric lighting company at Geelong.

Devon and Cornwall Electric Light Company.—Mr. Justice Chitty has appointed Mr. Edwards official liquidator of this company.

New Company.—The Commercial Underground Electric Company has been incorporated at New York. It is to construct, use, or lease telegraph wires.

Siam.—A Reuter's telegram dated Berne, June 12, states that the Siamese Government has notified its adhesion to the International Telegraph Convention.

Dividend.—The Eastern Extension Telegraph Company have declared an interim dividend on the old shares of 2s. 6d. per share, as well as 2s. 6d. per share on the new shares.

Royal Society.—On Thursday Mr. W. De La Rue, F.R.S., and Mr. H. Muller, F.R.S., were to read a paper before this society on "Experimental Researches with the Chloride of Silver Battery."

A Change.—Sir Charles William Siemens, F.R.S., has publicly given notice of his intention to drop his baptismal name of Charles, and desires to be known henceforth as Sir William Siemens.

Electric Light in India.—The electric light is to be introduced on the Madras Railway, and the necessary apparatus and materials are on their way from England, at least so says a contemporary.

Electric Lighting in Spain.—The Bilbao Town Council have ordered some arc and incandescent lamps from the Sociedad Espanola de Electricidad, with the object of making a trial of the electric light.

Business Notice.—The Western Electric Company, who are large manufacturers in America of telegraphic and telephonic instruments, electric bells, and other apparatus, have opened a London branch at 59, Moorgate-street.

The Duplex Electric Light Company.—A petition for the winding up of this company was presented on the 6th inst. by the British Trading Company. It is to be heard before Vice-Chancellor Sir James Bacon on the 23rd inst.

Mr. Spottiswoode.—We regret to say that the President of the Royal Society has the last few days been suffering from a severe attack of fever caught during a recent visit to Rome. The latest bulletins represent Mr. Spottiswoode as somewhat better.

A New Journal.—It is announced that a new journal, devoted to electricity, will make its appearance towards the end of this month. The title of this latest addition to the ranks of electrical journalism will be *Révue Générale d'Electricité.*

The Maxim-Weston Electric Company.—We understand the letters of allotment of the new issue of shares were posted on the 12th inst. This company has secured the lighting of the entire buildings of the Welsh Eisteddfod National Gathering.

Electric Lighting for the Suez Canal.—An Exchange Company's telegram from Paris states that M. de Lesseps has resolved to light the Suez Canal throughout its course by means of the electric light, in order to allow of the traffic through the canal being carried on day and night.

Messages for Mauritius.—The Eastern Telegraph Company (Limited) notify that a steamer leaves Durban for Mauritius and Madagascar on the 22nd instant. Messages for the above ports, intended for that opportunity, should be handed in not later than noon on the 21st instant.

The Incandescent System in France.—It is stated that a company has been started by some Englishmen in Lyons under the title of the Lyons Electrical Company. The objects are to supply electric lights on the incandescent system in and about that town. Swan lamps will be used.

The Telegraph in the Orange Free State.—The President, in his address on opening the Volksraad, expressed his hopes of a speedy conclusion of telegraphic and postal conventions, and recommended the construction by Government of a line from Colesberg to Bloemfontein, *viâ* Phillipolis, and thence *viâ* Harrismith to the Natal frontier.

Powder Magazine fired by Lightning.—A telegram from Scutari, Albania, dated June 8, says:—"The powder magazine of the fortress of Scutari was struck to-day by lightning. A great explosion followed, and a portion of the bazaar was destroyed. Many persons are reported killed." Later information says that ten soldiers and seven civilians were killed, and forty soldiers and fifteen civilians injured.

Telegraph Instruments Wanted.—The Highland Railway Company want tenders for the supply of telegraph instruments and fittings for one year, from the 1st July next. Forms of tender may be obtained on application to Mr. J. G. Bulmer, storekeeper, Inverness. Tenders, properly endorsed, sealed and addressed to the directors, must be lodged with the secretary, Mr. A. Dougall, not later than the 23rd inst.

Electric Lighting in the Provinces.—In the House of Commons on Thursday, June 7, Mr. John Holms moved for leave to introduce Bills to confirm provisional orders of the Board of Trade, under the Electric Lighting Act 1882, relating to Aston, Dudley, West Bromwich, Wolverhampton, Balsall Heath, Birmingham, Redditch, and Walsall. Leave was given; the Bills were read a first time, and referred to the examiners.

The Fisheries Exhibition.—Although only temporarily erected, we are informed that the buildings of this exhibition have been insured in the Phœnix Fire Insurance Company's Office, at an exceptionally low rate, owing to the careful manner in which the wires for the electric lights that are to be used for lighting purposes have been put up. The work of wiring was superintended on behalf of the Phœnix Company by Mr. Musgrave Heaphy, C.E.

Electric Lighting for St. Pancras.—The St. Pancras Vestry have published a notice to the effect that the Board of Trade have issued a provisional order giving them leave to supply electricity for public and private purposes within that parish, and that the Board intend to include this order in a confirmation Bill about to be introduced to Parliament. Copies of this order are to be had at the Vestry Hall, Pancras-road, N.W., at a cost of one shilling each.

The Flexion of Polarised Electrodes.—M. Gouy, in a recent note to the Academy of Sciences, describes a phenomenon which he has observed, viz., the flexion experienced by electrodes in the course of polarisation when they are formed of a thin metal plate, protected on one of its faces by a very thin layer of an insulating varnish. This peculiarity he has studied by two slightly different methods, with gold, and a saturated solution of sulphate of copper containing a little sulphuric acid.

Transmission of Power.—*L'Electricité* says:—"Another prize of 6,000 francs has been offered by the Compagnie des Mines et Cuivres de Mansfeld for the best system of transmitting power underground. The power transmitted must

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not be less than 10 horses, the distance being 1 kilometre. The motor is to be placed either underground or at the surface; in the latter case, the speed of the transmission shafting and pulleys must not be more than 100 revolutions per minute. Finally, the cost of erection must not exceed that which would be incurred by the use of a steam engine."

Magnetic Lines of Force.—The method of ascertaining the distribution of the lines of force by placing paper over a magnet and sprinkling iron filings on the paper is probably known to all our readers. It may be useful, and perhaps new to some of them, however, to learn how to fix the iron filings in the positions they take up with regard to the magnet. Substitute paraffined paper for ordinary paper, and when the filings are in position pass a piece of heated metal over them so as to melt the paraffin, and then withdraw it. The paraffin will cool and the filings be permanently held in position.

Vienna Electrical Exhibition.—In addition to the Danish Naval Department, we are informed that the War Department of that kingdom will exhibit in the field telegraphy section of this exhibition. Several Danish exhibitors have lately sent in applications for space, one of whom, Francis Lund, chief of the Department for Sea Mines and Torpedoes at the Arsenal in Copenhagen, has been appointed by the Danish Government as official representative of the Danish exhibitors. He is staying at present in Vienna in order to consult and arrange with the managing committee all details respecting the Danish Exhibition, which, according to his estimate, will occupy an area of 190 square metres.

British Guiana.—At the last meeting of the Court of Policy, says the *Colonies and India*, a letter was read from the West India and Panama Telegraph Company, thanking the Government for the favourable consideration shown to its interests, and protesting against the continuance of the subsidy being made dependent upon the through working of all connecting lines, it being urged that the company can exercise no control over those lines which do not belong to them, and pointing out that arrangements were in contemplation to lay new cables from Cuba to Demerara, which, if carried out, would materially improve the present means of communication. An order for the balance outstanding due to the company, 5,979 dollars, was passed by the Court of Policy.

Electric Lighting in Cardiff.—Mr. J. B. Braithwaite, jun., chairman of the Great Western Electric Light Company, writes as follows with reference to the note in last week's issue under this head:—"The Brush lamps there referred to were not used for lighting St. Mary-street, but were, I believe, supplied privately by Mr. Carr, of the Western Mail, to some of his friends. My company has a lighting station in Cardiff, and I am happy to say that, so far from the 'Brush' light being superseded, we are constantly adding fresh lights to our station. During last month we fixed eleven fresh arc lamps, and are now busy fitting up several additional ones, as well as incandescent lamps, run in groups on the arc circuit. I may mention that we have two 25 nominal horse-power Robey engines, both of which we expect to have fully employed this autumn."

The Resistance of Mercury.—The following is an abstract of an article by R. Lenz, in Wiedemann's *Bieblätter*, Vol. VI., p. 802, which appears in this month's *Journal* of the Society of Telegraph Engineers:—"A thermometer tube, 1·2 m. long, was widened out at either end into two cups, and was filled with perfectly pure mercury which had been thoroughly dried and free from air. The current was conducted to the cups by means of platinum hooks. The tube was placed in a piezometer, in which a pressure of 60 atmospheres could be attained, and which was surrounded with ice. Two platinum wires connected the platinum hooks with the binding screws of the piezometer. The resistances were measured by the Wheatstone bridge method, with a sine galvanometer of Kohlrausch, and an electro-dynamometer. The resistance of the copper wires could be neglected, that of the platinum wires varied from 0·48 ohm to 0·256 ohm, according to the diameter. The resistance of the mercury column was about 7·11 ohms. On increasing the pressure from 0 to 60 atmospheres, the resistance decreased by 0·02 per cent. per atmosphere. The decrease is very nearly proportional to the pressure. If the tube is filled by means of Weinhold's distillation apparatus in vacuum, the resistance in the first place is 0·12 per cent. smaller than if it is filled by sucking in the mercury."

Electric Lighting for Lighthouses.—According to an American paper, President Henry Morton of the U.S. Lighthouse Board, is reported to have stated that plans for testing the lighting of lighthouses by electricity are nearly completed, and the test will be made at the entrance to the lower harbour, New York, probably at one of the two Highland lights. He believed that arc lights would not be found to be servicable for coast and harbour illumination, mainly because they waver in intensity. The lights in American lighthouses are so arranged as to throw regularly intermittent flashes to the navigator, and if the electric light should die down it would show a series of irregular flashes, and that might be very confusing. Professor Morton has been carrying on a series of experiments with incandescent lights, with a view to reach the greatest possible light. He has succeeded in obtaining 400 candle-power. An incandescent light has thus been obtained powerful enough to conduct the experiment with. Two items of considerable expense remain. The great lenses used for the lamps now in the lighthouses, it is found, serve to dissipate instead of to concentrate the rays of an electric light, so that lenses must be ground especially for the electric light. Two dynamo machines also must be at the foot of the lighthouse, one to be kept in reserve if the other should fail.

Death of Sir J. R. Carmichael.—We regret to have to announce the death of Sir James Robert Carmichael, which took place in his town house, Sussex-place, Regent's Park, on Thursday morning, the 7th June, at the age of 66. He was born on the 11th June, 1817, and was the eldest son of the late Major-General Sir James Carmichael-Smyth, C.B., of Nutwood, Surrey, by marriage with Harriet, only child of the late General Robert Morse, R.E. He was educated at Charterhouse and at the Royal Military College, Sandhurst, and was formerly an officer in the Army. He succeeded his father as second baronet in 1838. Sir James resumed his family name of Carmichael only, by Royal license, in 1841. He was a claimant to the Scottish earldom of Hyndford. The first baronet received his title in 1821, for military services, having served under Sir David Baird, Lord Lynedoch, the Duke of Wellington, &c. He commanded the Royal Engineers in the Low Countries and Waterloo, and was some time governor of British Guiana. His father, James Carmichael-Smyth, M.D., physician to George III., assumed the additional surname of Smyth, and received the thanks of Parliament for his public services. Sir J. R. Carmichael married, in 1841, Louisa Charlotte, daughter of the late Sir Thomas Butler. He is succeeded in the baronetcy by his only son, James Morse, who was born in 1844. There is also a daughter living. The deceased baronet was well known in the electrical world, as

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chairman of the Submarine Telegraph Company and the Mediterranean Extension Telegraph Company, as well as a vice-president of the Electric Sun Lamp Company.

A New Insulating Compound.—Mr. C. W. Torr, of the firm of R. W. Winfield and Co., Birmingham, has recently taken out a patent for a new insulating compound. The inventor thus describes this new material in his patent:—"The essential constituents of the compositions constituting my invention are pitch, rosin, and Calais sand. These I mix in the proportions of about one part by weight of pitch, one part by weight of rosin, and two parts by weight of sand. The mixture of these materials is heated until the pitch and rosin are melted, and the semi-liquid mass is stirred until the melted pitch and rosin are thoroughly incorporated and the sand thoroughly mixed therewith. The composition is hard and somewhat brittle, and where it is likely to be exposed to concussion, or where it is desired it should be flexible, I give to it a slight flexibility by the addition of a small quantity of tallow, which is added to the other materials during the process of incorporation by heat. A composition containing one hundred parts by weight of pitch, one hundred parts by weight of rosin, two hundred parts by weight of sand, and sixteen parts by weight of Russian tallow, possesses sufficient flexibility for most purposes, and is not liable to fracture. As the addition of tallow causes the composition to soften and melt at lower temperatures than when the said composition contains no tallow, I reduce the quantity of or altogether omit the tallow where the composition is likely to be exposed to heat. By omitting the tallow and increasing the proportion of sand the composition may be made much harder, and not liable to soften at any temperature to which insulating compositions are ordinarily exposed." The number of the patent is 5129 for 1882.

Electric Discharges in Vacuum.—Herr J. Puluj, in a paper upon the streams of electrode matter, describes an apparatus by which he shows that electric discharges in vacuum can be hindered by the existence of static charges upon the walls of the vacuum space. The instrument consists of a tube of the form of a rectangle, into one of the sides of which are inserted two wire electrodes, about 8cm. from each other. Under a pressure of ·06mm. of quicksilver, electric discharges take place in the short side, in which are the electrodes, and also in the other sides of the rectangle. But if the tube in the neighbourhood of the electrodes is held between two fingers, the stream in that part of the tube is interrupted, and is strengthened in the other portions, though it may have to traverse a path perhaps five times longer than the shortest distance between the electrodes. The stopping of the discharge in highly rarefied spaces is often quoted as a proof of the untenability of the single fluid view of electricity. If, it is said, the electric current consists in the movement of an imponderable matter, the discharges ought to go on in the best vacuum, because the ether is always present. Against this view, it may be remarked that the discharges in a vacuum of constant value take place the more easily the further removed the walls of the space are from the cathode, and thus there is reason to suppose that discharges might take place even in the highest possible vacuum if it were not for the unavoidable existence of static charges upon the surface of the glass chamber. The origin of these charges may be looked for partly in the induction from the cathode, and partly in the direct transfer of static electricity by means of the particles of cathode precipitated against the glass.—*Wiedemann's Annalen.*

The Electrical Resistance of Glass.—In a note in our issue of the 26th May we gave the results of some experiments made by M. Foussereau to test the influence of tempering on the electrical resistance of glass. M. Foussereau gave some account of this method of experimenting at a recent meeting of the French Physical Society. He made use of test tubes, closed by a stopper. The current from a battery of from three to 100 volta elements was caused to traverse the thickness of these tubes, and was collected in a condenser of known capacity. The time required to communicate a known difference of potential to the armatures of the condenser was measured, the difference of potential being observed by means of a Lipmann electrometer connected to the two armatures. The most scrupulous precautions were observed to avoid all superficial conductivity. The experiments were enabled to be carried out for certain glasses as far as − 17 degrees. Bohemian glass was found to have from 5 to 20 times the conductivity of ordinary glass. Crystal, on the contrary, had 1,000 to 1,500 times more insulating power than the latter. Tempering exercised a very considerable influence on the resistance of certain glass. The author studied this influence by causing specimens of tempered glass and crystal to undergo a greater or less amount of baking. Their resistances at the same temperatures increased with the action of baking, until they became in certain cases 11 times greater. This increase in resistance became more and more marked according as the baking was hotter and more complete. It continued for some time after baking, the glass not resuming its definite molecular equilibrium directly. On the other hand, glass, whether tempered or not, which had not been heated for some time, preserved an invariable resistance. In these different experiments specimens of non-tempered glass afforded the terms of comparison.

Electrical Storms.—Speaking of the cyclonic storm which passed over the centre of the United States on the 22nd of last month, the *New York Herald* says:—"As the central area of the cyclone approached the Virginia coast, on Monday evening, a series of electric storms, or one grand electric storm, illumined the Atlantic seaboard from Virginia to New York, and violent thunderstorms were reported in Washington, Philadelphia, and New York. This brilliant and extended display was due apparently to the movement of a cool and dry stratum over the saturated surface winds, blowing from the south and east on the north-eastern margin of the cyclone, and the consequent changes of wind and temperature. The advance of the general depression with which these thunderstorms were associated was also indicated on Sunday evening at Philadelphia by the slow-moving cirrus and other clouds, while the central depression was several hundred miles distant in the south-west. But the most interesting and important phenomenon of the cyclone was that it signalled its own north-eastwardly advance by vivid electric flashes far beyond its centre. The meteorological significance of silent sheet lightning has recently been considerably discussed by scientists, with the generally accepted conclusion of experts that it is by no means a harmless display, but the signal of a coming storm, yet too remote for its thunder to be heard. This conclusion was strikingly confirmed on Monday night by the far-reaching electrical phenomena of the Virginia cyclone—a fact which forcibly suggests that the approach of many of our large cyclones, and even of the great tropical hurricanes, may be foreseen and foretold by their lightnings before instrumental indications justify a forewarning. The fiery portents of the great Cuba hurricane of September 5, 1882, were visible at Havana and Pensacola over twelve hours before the storm rose to its maximum force at these points or the barometer gave unmistakable warning.

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While our thunderstorms may be local (the lightning being electrical discharges from two adjacent clouds), the phenomenon is often extended over a whole section of the country, with most serious consequences. They deserve, therefore, much more careful investigation than they have yet received. It would be a great aid to the popular understanding of the movements of thunderstorms and their relation to the large cyclones if the former were as regularly charted as the latter."

Experiments with Dynamo Machines.—M. J. Pollard has recently published the results of experiments made by himself, with the aid of Engineer Garnier and Lieutenant Journet, on board one of the ships of the French Navy. They experimented with machines of the Gramme type, having the inductors in the circuit, and their theory led them at the outset to the establishment of the following fundamental principle:—The resisting-couple developed during the working of a dynamo-electric machine is merely a function of the current which circulates in the coils, and, in consequence, the current generated is constant and independent of the behaviour or resistance of the external circuit, when the motor couple is itself constant. The numerical determination of the laws regulating the connection between current flowing in the inducing and induced coils and the electromotive force per revolution, $\frac{E}{n}$, on the one hand, and the value of the motor couple, C, on the other, necessitated the use of measuring apparatus, which they were without. They were consequently obliged to treat the question indirectly by experimentally considering the case in which a steam motor was possessed of a constant static couple, whatever were the demands made on it. Under these conditions the constancy of the current was verified in external circuits of various resistances, for which the speed of the machine was varied within wide limits. The following table gives the results of one of the experiments, in which the external circuit was composed of a hand lamp; the distance between the carbons was lengthened progressively from 0 to 6 millimetres (a millimetre is equal to about 1-25th inch), whilst the speed of the machine rose from 500 to 700 revolutions without the intensity of current indicated by the deflections of a small galvanometer varying in any marked degree. The Gramme machine was driven direct by a Brotherhood engine supplied with steam by powerful boilers, which maintained a constant pressure. As the introduction of steam into the cylinders was regulated at a fixed quantity, it might be taken for granted that the average power exerted on the pistons, and, consequently, the motor couple, was constant during the experiment:—

Distance between carbons.	Speed of Machine.	Deflection of Galvanometer.
In contact	436	59 degrees.
1 mm. apart	550	56 „
2 „ „	600	56 „
3 „ „	650	56 „
4 „ „	675	56 „
5 „ „	700	55 „
6 „ „ (break)	726	54 „

The Abbé Laborde.—In a recent issue of *Cosmos Les Mondes*, M. l'Abbé Moigno writes in the following terms of the death of his *confrère* and friend, L'Abbé Laborde, who died at Nevers on the 18th of May, at the age of seventy-five:—"The Abbé Laborde was, above all things, a physicist, and an experimental physicist of great ability, making his own apparatus when needful and when his resources did not place them within his reach. In the vast domain of physics, which comprises mechanics, heat, light, as well as photography, electricity, &c., he made a large number of inventions and original discoveries of very great importance. I will only enumerate a few. Let me revert to the momentous time when the need of measuring directly the incalculable velocity of light made itself felt, when great geniuses, Arago, Foucault, and Fizeau, simultaneously strove to solve the difficult problem; and its solution hovered, so to speak, in the air ready to reveal itself at several points, at the same time. It was to M. l'Abbé Laborde, however, that it first revealed itself, and here is what I can, what I ought to add in my *Repertoire d'Optique Moderne*, Vol. III., p. 1,162, to the account of that very celebrated experiment of M. Fizeau's. 'A modest man, M. l'Abbé Laborde, professor of physics at the small school of Corbigny, conceived and discussed, some five or six years ago, the experiment so admirably carried out by M. Fizeau. On this subject he wrote, five or six years before, to M. Francois Arago, a letter, lost, alas! in the huge portfolio of the observatory (like to the sea into which all the rivers are emptied and yet it never overflows); brought to light again when it was too late, and which I am glad to publish, because it gives my friend the undoubted right of priority, and a glorious title. It would be impossible for me to analyse even rapidly the innumerable communications to my dear *Cosmos* which my friend made, all sparkling with new and pregnant ideas. I will at least recall to mind the learned explanation which he was the first to give of this mysterious passage in the Book of Psalms: *Fecit fulgura in aquas;* he changed the lightning into water, and made water with the electricity of the atmosphere.' M. l'Abbé Laborde was the first to discover, and prove by direct experiment, that the electric current in penetrating to the depths of a mass of water vapour causes therein a lowering of temperature and condenses it into water. Up to his time it was only known that discharges of electricity in the atmosphere were very often followed by a heavy fall of rain. The news of the death of my eminent *confrère* has caused me great sorrow; it has left a great blank in my life, as well as a certain remorse at not having made sufficient effort to obtain for him that justice which was his due. L'Abbé Laborde should have been made a chevalier of the Legion of Honour twenty years ago. A pious priest, even more edifying than learned, he will receive in heaven, if he has not already received it, the only recompense worthy of him."

Winding Electro-magnets.—Professors W. E. Ayrton and John Perry have recently made some interesting experiments on the winding of electro-magnets, with a view to determine which mode of winding a given length of wire on an iron bar gave the strongest electro-magnet for the same current. Four bars of iron, each 12in. long, were cut from the same rod ⅜in. thick, and an exactly equal length of wire was wound on the four bars respectively, in the following way:—1. Wire wound equally over the whole length. 2. Wire coned towards each end. 3. Wire wound equally over half the iron bar, leaving the other end bare. 4. Wire wound on one half but coned towards the end. Electro-magnet No. 1 was put so that its axis was at right angles to the axis of a small magnetic needle and passed through the point of suspension of the needle, which was suspended so as to move freely in a horizontal plane, and far enough away that the magnetic field due to the electro-magnet No. 1, when magnetised by passing a current through it, was nearly constant over that portion of the field in which the little suspended needle moved when deflected. A constant current was now passed through the coil on No. 1, and the deflection of the little needle observed when No. 1 was placed at different distances from the centre of the test-needle, the axis of

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No. 1, however, always remaining in the same line. Under these circumstances it is well known that the strength of the field produced by No. 1 at the centre of the test-needle is approximately proportional to the tangent of its deflection. Experiments were now made in a similar way with electro-magnet No. 2, and with each end of No. 3 and of No. 4, the same current as was employed with electro-magnet No. 1 being used in all cases, and which was much below the saturating current. It was found that the effect of coning the wire was to produce a strong field very near the pole, but that the force fell off very rapidly as the distance from the pole increased. The uniformly coiled magnet No. 1 was found to produce the most powerful field at considerable distances from the end of the electro-magnet, while for points nearer the magnet, but still at a distance of about 3in. from it, the covered end of No. 3 magnet produced the strongest field, the next strongest being produced by magnet No. 2 with the wire coned towards each end. To ascertain the force which each magnet would exert on an armature, experiments were made, and the following results obtained, the current flowing through the coil in each case being exactly the same, as well as the armature employed:—

Magnet.	Weight required to detach the armature from the covered end of the magnet.
No. 1	45 ounces
„ 2	57 „
„ 3	57 „
„ 4	77 „

These results confirmed the previously-ascertained fact that the field produced by the covered ends of the electro-magnets numbers 2 or 3 at distances near the pole was much stronger than that produced by No. 1. They also showed that for very small distances the covered end of No. 4 produced the strongest field. From these experiments Messrs. Ayrton and Perry conclude that with a definite iron core, a definite length of wire to be coiled on it, and to be traversed by a definite current, the mode of coiling to produce the largest field depends entirely on the distance from the end of the electro-magnet at which the field is to be produced. With the particular magnet employed by them it is seen that, at distances from the end of the magnet very small compared with the length of the core, the wire should be coiled up at the near end of the core; to create a field at a distance from the end of the magnet equal to about a third of the length of the magnet, it is better to coil the wire uniformly over one-half of the core than to cone it up at the near end; while for distances from the end of the magnet, equal to, or greater than, about $\frac{1}{3}$ of the length of the core, the uniform mode of winding is the best. The experimenters thank two of their students, Messrs. Sayers and Pink, for their cordial assistance in the above experiments, a more detailed account of which, with illustrations, will be found in the *Philosophical Magazine* for June.

Electrolytic Experiments.—In further continuation of our recent note under this head, we take the following from the *Journal* of the Chemical Society for May, describing some experiments made by A. Bartoli and G. Papasogli, on the electrolysis of solutions of hydrofluoric acid and of potassium antimonate, with carbon electrodes, the original description of which appeared in the *Gazzetta*, Vol. 13, pp. 22—27:—(1). *Electrolysis of Hydrofluoric Acid:* When wood-charcoal or gas-retort carbon, after purification by chlorine, is used as the positive electrode in the electrolysis of aqueous hydrofluoric acid, it is partly disaggregated, swelling up in the immersed part, and becoming so brittle that after a while it splits up by its own weight into rather large fragments, whereas the carbon at the negative electrode remains quite unaltered. On repeatedly washing the altered carbon till the wash-water is no longer acid, then drying it at 100deg., reducing it to impalpable powder, repeatedly boiling it with hydrochloric acid, and once more thoroughly washing it with water, it exhibits the following properties:—1. It dissolves partially, with dark-red colour, in strong sulphuric acid. 2. It is attacked by a hot solution of sodium hypochlorite, yielding sodium fluoride, mellic acid, and the usual derivatives of the latter. 3. In addition to carbon, hydrogen, and oxygen, it contains fluorine, amounting to about 3 per cent. of the disaggregated carbon, and not due to electrolysis of mineral matter, inasmuch as the carbon used in the experiment did not yield on ignition any perceptible quantity of ash. When graphite is employed as positive electrode in the electrolysis of strong aqueous hydrofluoric acid, the immersed portion swells up, becomes pappy, and quickly disintegrates; and the disintegrated portion, when purified in the manner above described, forms a black powder, which swells up considerably when heated, is insoluble in all solvents, and contains carbon, oxygen, hydrogen, and fluorine.—(2). *Electrolysis of Potassium Antimonate:* When a solution of this salt, obtained by heating the acid antimonate in large excess with caustic potash-lye, is decomposed by a battery of eight Bunsen's elements, the positive electrode being formed of wood-charcoal or retort-carbon, large quantities of gas are evolved at the negative electrode, and only a small quantity at the positive, which at the same time is strongly attacked, while the electrolyte becomes deep black, and deposits a black sediment, Ω, soluble in a large quantity of water. On filtering the liquid, adding the black wash-waters of the precipitate Ω, then concentrating on the water-bath, and adding excess of hydrochloric acid, a copious precipitate, B, is formed, which, after washing and drying, contains only traces of antimony, and exhibits the following properties:—1. After drying at 100degs. it contains carbon, hydrogen, oxygen, and antimony. 2. It dissolves in water and in alkaline hydrates, forming deep black solutions, from which it is completely precipitated by mineral acids. 3. It dissolves with rise of temperature in aqueous potassium hypochlorite, forming mellic acid and other benzocarboxylic acids, together with potassium antimonate. This substance being analogous in modes of formation and in properties to mellogen, the authors distinguish it by the name of *Stibiomellogen*. When graphite is used as positive electrode in solutions of potassium antimonate, large quantities of gas are likewise evolved at the negative, and very little at the positive electrode. At the end of the experiment, the graphite is found to be much disintegrated, and a copious black deposit, Ω, is found at the bottom of the voltameter, surmounted by a nearly colourless liquid containing small quantities of mellic acid and its derivatives. The deposit Ω, after washing and drying, is found to consist of a mixture of graphite and a new compound of carbon, hydrogen, oxygen, and antimony, which the authors designate as *Stibiographic acid*. Its composition and properties will form the subject of a future investigation. From the results obtained in this and in preceding investigations, the authors infer: (1). That in the electrolysis of nitric, phosphoric, arsenic, and antimonic acids and their salts, the first and third yield with electrodes of wood-charcoal or retort-carbon mellogen free from nitrogen and arsenic—whereas with graphite electrodes they yield graphite free from nitrogen or arsenic—and that the second and fourth give with charcoal or retort-carbon electrodes, phospho- and stibio-mellogen respectively—whereas with graphite electrodes they give phospho- and stibio-graphitic acid.

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ELEMENTARY ELECTRICITY.—XII.

(CONTINUED FROM PAGE 79.)

All bodies possess a certain amount of resistance, and only a certain amount, though the interval between the best conductors (such as copper) and the best insulators, or worst conductors, such as sulphur or paraffin wax, is very great indeed. The resistance of a bar of glass is not less than 600,000,000,000,000,000,000,000,000 times that of a bar of copper of the same dimensions.

The first measurements of the resistance of conductors were made by Henry Cavendish, who not only compared the resistance of metallic wires but also of liquids (electrolytes), especially of solutions of common salt. These measurements were undertaken mainly in connection with his experiments on the torpedo, which led to the measurement of the resistance of sea water. From Cavendish's results it appears that the conductivities of saline solutions of different strengths are nearly proportional to the per centage of salt present, a fact recently rediscovered by Kohlrausch. Though Cavendish employed a Leyden jar for his source of electricity, and measured the resistance of the conductor simply by sending the charge of the jar through the conductor and his own body, and estimating the intensity of the shock; his results, so far as they apply to solutions of salts, were not improved upon until Kohlrausch took up the matter in 1857. Cavendish appears to have understood the theory of divided circuits and practically to have arrived at Ohm's law, though he did not formally enunciate the law.

The relation between the electromotive force in a circuit and the current produced by it is expressed by Ohm's law. As ordinarily enunciated this law is as follows:—

The current in any conductor is equal to the electromotive force between its extremities divided by its resistance.

From this it follows that the current in any simple circuit is equal to the whole E.M.F. around the circuit divided by the whole resistance of the circuit.

Ohm's law may be converted into the following statements:

The resistance of a conductor is equal to the electromotive force between its extremities divided by the current produced in it.

This statement furnishes what may be called a *quantitative* definition of resistance, or a definition of the measure of resistance, since current and electromotive force are both quantities which we already know how to measure. The definition previously given may be regarded as a *qualitative* definition of resistance telling us what kind of quantity resistance is, but not enabling us to measure it.

The unit of resistance is the resistance of a wire in which a unit electromotive force produces a unit current. The unit of resistance adopted in practice is called an ohm.

It may appear at first sight that Ohm's law *simply* gives a definition of the measure of resistance, and this is all that is formally stated; but, as in Newton's laws of motion, there is more implied in the law than appears on the surface. The fact that resistance is an attribute which may be assigned to a conductor without qualification as regards the current flowing in it implies that the resistance of a conductor is constant so long as its temperature, mechanical condition, &c., remain unchanged. Hence, in the same conductor the current will be proportional to the electromotive force between its extremities. Therefore, if the E.M.F. be doubled, the current also will be doubled, and so on, and this is the law implied in the statement.

The clearest conception of the meaning of Ohm's law may, perhaps, be gained by considering what is implied in its denial. Thus, if we deny that the current is proportional to the electromotive force, we may hold that, if the E.M.F. is increased, the current will be increased in a higher or in a lower ratio. Both these views have been maintained. According to the first hypothesis, the resistance of a conductor will diminish as the current in it is increased, as though the increased E.M.F. partially broke down the resisting power of the conductor. According to the second hypothesis, the resistance will increase with the increase of the current. Now, the measurement of the resistance of a conductor is an operation which can be carried to a higher degree of accuracy than any other physical measurement, except, perhaps, the measurement of mass by weighing. Thus, the equality of the resistances of two wires can be ascertained to within one part in a million. It is therefore possible to apply very severe tests to Ohm's law, but the law holds good under the most severe tests which have yet been applied.

When a current flows along a wire and can only enter or leave the wire by the ends, there will be the same current across every section of the wire. If the wire be of the same material throughout and of uniform thickness, there is no reason why the potential should fall more rapidly in one part of the wire than in another. Thus, there will be a steady fall of potential at a uniform rate, from the end at which the current enters to that at which it leaves the wire. Hence, the difference of potential between any two points in the wire is proportional to the distance between the points. But the current in every portion of the wire is the same; hence, for any length of the wire the difference of potential between its extremities is proportional to its resistance, and therefore the resistance of any portion of the wire is proportional to its length.

If the resistances of a round wire and a ribbon of the same material and having the same sectional area be compared, they will be found to be the same, length for length, but if the sectional area be the same, the surface of the flat ribbon will be very much greater than that of the round wire. Hence, it follows that the resistance of a wire depends on its sectional area and not on its surface, and the conduction of electricity is a phenomenon which takes place uniformly throughout the substance of a conductor and not on its surface. It follows, therefore, that two wires of the same length, material, and section, placed side by side, and having both their extremities joined, will be electrically equivalent to a single wire of double the sectional area of either, and so on. But if a given electromotive force act between their extremities, the two wires will carry twice the current that either wire would carry, and so on if there are more than two wires. Hence, the resistance of the compound conductor will be inversely proportional to the number of wires. It follows, therefore, that the resistance of a single wire of given length and material will be inversely proportional to its sectional area. Hence:—

The resistance of a conductor of uniform section is directly proportional to its length, and inversely proportional to its sectional area.

So far we have considered the current per unit area of the section of the conductor to be always the same. The true test of Ohm's law lies in altering the strength of the current per unit area of the conductor, or what may properly be called the *intensity* of the current, and ascertaining whether the resistance of the conductor as measured by the ratio of the electromotive force between its extremities to the current produced remains the same. A very simple method of carrying out this experiment was proposed by Clerk Maxwell, and the measurements were carried out by Professor Chrystal. Five coils, which we may call A, B, C, D, and E, were wound so that each had as nearly as possible the same resistance (viz., 30 ohms). The equality of their resistance was first tested, and the small differences found were registered for the correction of the final result. The coils A and B were connected in series, that is, end to end, so that the same current flowed through each in succession; C and D were similarly connected, and the two compound conductors were then connected in multiple arc or parallel circuit, that is, so that the current could divide itself, and part flow through A and B, the other part flowing through C and D. The resistance of the four conductors so connected was then compared with that of the single coil E by the Wheatstone bridge method, which will be explained later on. In this arrangement the electromotive force between the extremities of any of the coils A, B, C, or D is clearly one-half that between the extremities of the compound conductor; that is, one-half of that which would exist between the extremities of the coil E, if the latter were put in the

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place of the compound conductor. If Ohm's law be true, but not otherwise, the current through each of the coils of the compound conductor will be half that which would flow through the single coil E, and hence the whole current through the compound conductor, since it possesses two branches, will be the same as through a single coil with the same E.M.F. between its extremities. Hence the resistance of the compound conductor will be the same as that of a single coil. By an ingenious arrangement, it was possible to compare any one of the five coils with the other four arranged as above described, and although a difference of resistance of one part in 500,000 could easily be detected, no error could be found in the accuracy of Ohm's law.

But a much more severe test, based upon the same principle, was applied to Ohm's law by Professor Chrystal. Instead of employing a combination of four equal coils, which are simply equivalent to a single wire of double length and double section, and comparing this with a coil equal to each of the four, Professor Chrystal employed two wires, one long and thick, the other short and very thin. By means of a rapid commutator of special design, he compared the resistances of these two wires in rapid succession when very feeble currents were passing through them, and when very strong currents were passing, and found the ratio of the resistances the same in the two cases. The strong currents raised the temperature of the fine wire to bright redness, but the feeble currents were sent through before the wire had time to cool, and then the strong currents again. The resistances of the wires bore the same ratio to each other for both sets of currents.

Def. The conductivity of a conductor is the inverse of its resistance, *i.e.*, if the resistance be denoted by R the conductivity will be represented by $\frac{1}{R}$.

When a number of conductors are connected so that the same current flows through each in succession, they are said to be arranged *in series*, and the *resistance* of the compound conductor is the sum of the resistances of its constituents.

When a number of conductors are so connected that the current divides itself between the conductors, part flowing through one and part through another, they are said to be arranged *in multiple arc*, and the *conductivity* of the compound conductor is the *sum of the conductivities* of its constituents.

Thus, if conductors whose resistances are R_1, R_2, R_3 . . . are arranged in series, the resistance of the system will be $R_1 + R_2 + R_3 + \ldots$. If they are arranged in multiple arc, the conductivity of the system will be

$$\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \ldots .$$

and its resistance will be

$$\frac{1}{\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \ldots} .$$

A number of battery cells are said to be arranged in series when the same current flows through each in succession, the zinc of one cell being connected to the copper (platinum, carbon, &c.) of the next, and so on. In this case the electromotive force of the batery is the sum of the electromotive forces of the several cells, while its resistance is the sum of their resistances.

A battery is connected in multiple arc when all the zinc plates are connected together as well as all the copper (platinum, carbon, &c.) plates, so that the current is divided between the cells. If all the cells have the same E.M.F. and the same resistance, the E.M.F. of the battery will be equal to that of one cell, while the resistance will be inversely proportional to the number of cells.

Sometimes a battery is so connected that several sets of cells are connected in series, and the several series then treated as single cells and connected in multiple arc. Suppose there are *nm* cells, each of electromotive force E and resistance *r*, and that they are arranged in *m* series, each series containing *n* cells, and let the *m* series then be connected in multiple arc and the terminals of the battery connected by an external conductor of resistance R. The E.M.F. of each series of *n* cells will be *n* E, which will therefore be the E.M.F. of the whole battery. The resistance of each series will be *nr*, and therefore the resistance of the whole battery will be $\frac{nr}{m}$. Hence the resistance of the whole circuit will be $\frac{nr}{m} + R$, and by Ohm's law the current C will be given by the equation,

$$C = \frac{nE}{\frac{nr}{m} + R}$$

The quantity $\frac{nr}{m}$ is sometimes called the *internal* resistance of the battery, while R is called the *external* resistance of the circuit. For a given number of cells—that is, for a given value of *nm*—the current will be greatest when the external and internal resistances are as nearly as possible equal.

Thus, if there is a battery of 80 Grove cells, each having a resistance of ·2 ohm (the ohm is a unit of resistance to be defined later on), and it is desired to send a current through an electro-magnet having a resistance of 1 ohm, the best arrangement will be to set up the battery in four series each of 20 cells. The resistance of each series will then be 4 ohms, and that of the whole battery 1 ohm, that of the whole circuit being 2 ohms, while the E.M.F. will be 20 E (the E.M.F. of a single cell being denoted by E), and the current will be 10 E.

If the battery is arranged so that all the cells are in series the E.M.F. will be 80 E, the internal resistance 16 ohms, and the current will therefore be $\frac{80\,E}{17}$.

If the battery be all in multiple arc the E.M.F. will be E and internal resistance $\frac{1}{400}$ ohm. Hence the current will be $\frac{E}{\frac{1}{400} + 1}$ or $\frac{400\,E}{401}$.

If the battery be arranged in 16 series of 5 cells each, the resistance of each series will be 1 ohm, the resistance of the whole battery $\frac{1}{16}$ ohm, and its electromotive force 5 E. Hence the current will be $\frac{5\,E}{1\frac{1}{16}} = \frac{80\,E}{17}$, which is the same as when the battery is all in series.

Comparing the four cases we have for the several currents $10\,E, \frac{80\,E}{17}, \frac{400\,E}{401}$, and $\frac{80\,E}{17}$. These are in the ratios of $\frac{1}{40} : \frac{1}{85} : \frac{1}{401} : \frac{1}{85}$.

When a number of battery cells are connected in multiple arc, or, as it is sometimes expressed, in parallel circuit, so that the conductivity of the battery is the sum of the conductivities of the several cells, while the electromotive force of the whole battery is simply that of one cell, the battery is sometimes said to be arranged "*for quantity.*" This is because the battery is capable of sending a very great current through a short thick wire of very small resistance, for though the E.M.F. is only that of one cell the circuit possesses such a small resistance that the current is very great. The whole arrangement is analogous to a very large channel which is capable of delivering a very great quantity of water per minute, though the head of water may be very small.

When the cells of a battery are connected in series, so that the resistance of the battery is the sum of the resistances of the several cells, while the E.M.F. of the battery is the sum of the electromotive forces of the cells, the battery is sometimes said to be arranged *for intensity.* Such an arrangement can send a considerable current through a conductor of great resistance, as, for example, a long telegraph line; but a battery arranged in this way is not capable of sending so great a current through a wire of very small resistance as when the cells are arranged in "multiple arc." If we wish to pump a stream of water through a very great length of

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very fine tube, a pump with very small suction and delivery valves, and worked at very high pressure, will be best suited to our purpose; but if we wish to pump a great body of water through a comparatively short length of pipe of great diameter, we must select a pump with very large valves, though the pressure at which it is worked may be much less than in the former case, otherwise the "internal resistance" of the pumps will prevent our obtaining more than a very small stream of water, notwithstanding the low resistance of the pipes. As before stated, a given number of battery cells will produce the greatest current in a given conductor when the cells are so arranged that the "internal resistance" of the battery is equal to the resistance of the external conductor.

Though we may speak of a battery arranged "for quantity" or "for intensity," we must avoid the error of speaking of "quantity currents" and "intensity currents." A current is completely defined by the number of units of electricity which pass across any section of the conducting circuit in a second, and two currents can differ from one another only in this respect. The one current may be produced by a high electromotive force in a circuit of great resistance, and the other by a comparatively low electromotive force in a circuit of correspondingly low resistance, but if the total quantity of electricity passing per second in each circuit is the same the currents are equal. If in some parts of the circuit the conductor is very thin, and at other parts very thick, the amount of current *per unit area of the section of the conductor* will differ in different parts, and we may regard the current as more *intense* when the section of the conductor is smaller, but using the word in this sense the same current may have a high intensity in one part of the circuit and a low intensity in another. This is the sense in which we have above used the word intensity as applied to currents of different strengths per unit area of the section of the conductor, but it is not the sense in which the phrases "intensity currents" and "quantity currents" have been generally, but erroneously, employed.

CURRENT ENERGY.—V.

BY OLIVER HEAVISIDE.

(CONTINUED FROM PAGE 437, VOL. X.)

The mechanical forces between conductors carrying currents, the induction of currents, Joule's law of the generation of heat, and the principle of the conservation of energy are all intimately connected. We cannot, in fact, isolate the mechanical forces from the induced electromotive forces without setting up artificial barriers, to be afterwards taken down. Yet it is necessary, since we cannot treat every part of a subject at the same time, to make a beginning somewhere, by selection of some facts and temporary exclusion of others, and the question presents itself, where to make a starting point for the induction of currents from the theoretical point of view. It is not so much a question of what are the laws of induction, though they are of course involved in the matter, as how to exhibit them and their connections with other electro-magnetic phenomena in a complete theory based upon the simplest and least number of experimental laws, and in what order to take the latter.

Now, in building up a consistent theory to embrace a number of facts of a certain class (complete relatively, that is to say, by a process of abstraction) there may be a large choice of methods. As all roads were said to led to Rome, so all truth is consistent, and by however roundabout a method we go to work we shall arrive at the same results on the way or in the end, if we are working correctly and not trusting to unsound hypotheses. From a group of experimental facts we may divine a certain relation, and by generalising it from the particular cases observed, make it a law, empirical so far, *i.e.*, not deducible from previously known laws at the time, though it may become so later. Such a law is that of gravity, though so long since its discovery it has not been satisfactorily explained by more easily understood laws. Ohm's law is also without explanation, whilst, on the other hand, the gaseous laws have been explained dynamically, as Newton's law of gravity and Ohm's law may be some day.

In general several such experimental laws are required to form the framework of a complete theory, though two or three may suffice to make considerable progress. Thus in electrostatics, after learning that electricity is a physical magnitude capable of measurement, that charges may be added and subtracted, the addition to this of the law of force between two concentrated charges, as ascertained by means of Coulomb's torsion balance, generalised to apply to all cases of electricity distributed in a single dielectric, enables us to at once apply the theory of the potential in its general aspect, and to find the distribution of force and the potential energy in the case of any arbitrary distribution of electricity. Add to this, further, the division of bodies into conductors and non-conductors, thus necessitating that in a state of electrical equilibrium there can be no electric force in any part of a conductor, and that therefore the potential of each insulated conductor or of each group of conductively-connected conductors must be a constant, and we have the means of determining the distribution of electricity in practical cases. To this add the further law relating to the difference of capacity of different dielectrics, and we are enabled to calculate the modifying influence on the field of force produced by varying dielectric capacity, and we have got nearly as far as the mathematical theory of electrostatics goes at present. There are plenty of facts outside the theory, but so far as it goes it is complete and consistent, and the facts excluded relate in the main to phenomena observed during the change from one state of equilibrium to another, on the borderland between purely static and purely dynamic phenomena.

Now, we might arrive at just the same results by other methods. Thus, in the theory of the influence of varying dielectric capacity above mentioned, instead of putting Faraday's law at once into a mathematical form, and starting with it, as Sir W. Thomson long ago did (introducing the dielectric constant K into the potential and force equations), we may try to do without it by assuming that the law of force between two charges is exactly the same for any dielectric, but that there are an immense number of small conducting particles embedded in a dielectric. After long travail, we shall find that this hypothesis leads eventually to Faraday's law. The hypothesis may be really true, but the mathematical theory is much simpler without it altogether.

There is an analogous case in the theory of induced magnetisation. The simplest method of laying down the theory is to start with Faraday's idea that different bodies conduct magnetic force differently, and to at once introduce a co-efficient to express this conductivity (the magnetic permeability, &c.). Calling the magnetic force as thus modified, that is $\mu \times$ force, the magnetic induction, we find that the induction is a flux of no convergence, or is distributed in closed tubes, and we have magnetic force producing magnetic induction in heterogeneous media, just as electromotive force produces current in similarly heterogeneous conducting media. But we may arrive eventually at the same result, which Maxwell thought best represented Faraday's ideas, by making the induced magnetisation the object of attention in the first place, and not the magnetic induction.

In these and similar cases the best course to pursue is to adopt that initial hypothesis which leads to the general results in the most direct manner, provided, of course, the hypothesis be free from objection.

In the theory of electro-magnetism, there is considerable choice of methods. As regards the electro-magnetic forces alone, we may find a law of force between a pair of current elements which will enable us to deduce the force acting upon any complete circuits. The investigations concerning the imaginary force between a pair of elements are usually very complex, and there is besides a grave objection. For we have no reason to believe that current elements can be isolated in the same way as charges of electricity may be (viz., on insulated conductors separated by a dielectric from all other charges). The current elements of course exist, but never independently of all other elements, if currents are always closed. As a consequence, there is an indefinite choice of formulæ for the

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force between a pair of elements, which is essentially indeterminate, a definite formula being obtainable only by making some pure assumption.

But a knowledge of the force in question is not required, even if it could be definitely found, and it is preferable to start with closed circuits and keep to closed circuits. Thus, all the mechanical forces between currents and currents, and currents and magnets may be based upon the law of the equivalence of a small closed current and a little magnet as regards the forces they exert; or we might do without the magnet altogether. Then, with a knowledge that currents are quantitatively expressible, have direction, and follow closed paths, we may, by geometrical or analytical reasoning regarding the properties of lines and surfaces, deduce all the rest, aided in particular by Ampère's device, whereby a finite linear circuit is replaced by any number of other circuits forming a network externally bounded by the original circuit, a process which has many important applications, and is of great assistance in various complex questions. Without further laws to help us, for we have no corncern with *how* the currents are obtained, we can develop the whole theory of the quantitative and directional relations of current and magnetic force, and of the v.-potential of current, and calculate the electro-magnetic forces, and the potential energy of any distributions of current, with respect to those forces. As regards a pair of linear currents, we find that the forces between the conductors may be found from a scalar function whose value depends upon the size, forms, and relative position of the circuits, multiplied by the strengths of the currents, say $M\,C_1C_2$, where M is the function mentioned. The mutual potential energy of the two currents is $-M\,C_1C_2$, and its rate of decrease as the circuits are shifted measures the rate of working of the electro-magnetic forces during the displacement, and consequently the forces concerned. The most readily intelligible form for the potential energy is in terms of the amount of induction or number of lines of induction through the circuits. The unit current in the first circuit sends the same amount of induction through the second as the unit current in the second does through the first, and this quantity is the M in the potential energy, reckoning the positive direction through a current to be that in which a free N. pole would travel through it under the action of its magnetic force.

From a pair of linear circuits we easily pass to the case of any distribution of currents, and we find the potential energy of two systems C_1 and C_2 to be $-$ T, where

$$T = \frac{1}{2}\Sigma\,\overline{A_1C_1} + \frac{1}{2}\Sigma\,\overline{A_2C_2} + \Sigma\,\overline{A_1C_2}$$

$$= \frac{1}{2}\Sigma\,B_1^2 + \frac{1}{2}\Sigma\,B_2^2 + \Sigma\,\overline{B_1B_2}$$

where A_1 and A_2 are the v.-potentials, and B_1, B_2 the magnetic forces, and space is divided into volume elements. But the most convenient form for two linear circuits is

$$T = \frac{1}{2}L_1C_1^2 + \frac{1}{2}L_2C_2^2 + M\,C_1C_2$$

where M is the same quantity as before, and L_1 L_2 are the corresponding quantities for the circuits taken separately. C_1 and C_2 are now the integral currents, not the current densities.

We have now to take down the artificial barrier set up in dealing with the electro-magnetic or mechanical forces. The currents were presumed to be given constant, and to remain constant during relative motion, and although work done by the electro-magnetic forces has been estimated, no account has been taken of other work in the system, as in keeping up the currents, or of the principle of conservation of energy. But currents do not remain in general of constant strength when in motion in a magnetic field, the changes in the currents being the induced currents, and it becomes absolutely necessary to enlarge the field of view.

There are several methods of laying down the laws of induced currents. If we were to choose that method which leads most easily and directly to the required laws, we should employ Maxwell's dynamical method, which exhibits the whole subject in a concise and comprehensive manner, whilst both the electro-magnetic actions and the electromotive forces of induction are deduced in the simplest possible mode. But it can scarcely be said that the cardinal assumptions of the dynamical method, that the energy of a current system is kinetic energy, that the system is a dynamically connected system, in which currents correspond to velocities, and that the expression for the energy does not contain products of the velocities of the geometrical and the electric variables, are sufficiently simple to justify us in selecting the method to start with. The dynamical method should rather follow other methods, which, if less direct, are more easily understood in the earlier stages.

The laws of induction were first completely quantitatively established by J. Neumann, who took for his basis Lenz's law, which was a generalisation from a comparison of the results of obtaining induced currents by the relative motion of a circuit (the secondary), without a permanent current, and of a primary circuit containing a current kept up by a battery. Now, if we grant that a current is induced in the secondary by relative motion of the circuits, it must be in either one direction or the other, and the electro-magnetic action set up between the induced and the primary current must, therefore, be such as either to resist or assist the motion. If the latter were the case, it would follow that the secondary circuit, when at rest, and with, therefore, no current in it (the primary being also supposed at rest), and with no force acting on it, would be in unstable equilibrium. For the least displacement of the secondary circuit, either to or from the primary, would call up forces increasing the displacement, and the secondary would continue to approach or retreat from the primary circuit, according to its initial motion. Such a state of unstable equilibrium being plainly inadmissible, it follows that the direction of the induced current, if there is any, must be such that the mutual forces between it and the primary resist the motion. This principle, applied to the motion of either primary or secondary, constitutes Lenz's law.

In reference to Neumann's investigations, Maxwell remarked that a step of still greater scientific importance was soon after made by Helmholtz and Sir W. Thomson, who showed that the induction of currents could be mathematically deduced from the electro-magnetic actions of Oersted and Ampère by the application of the principle of the conservation of energy.

But it must not be concluded from this that, given the electro-magnetic forces, and the truth of the general principle named, nothing more is needed to build up the whole science of the induction of currents. The statement sometimes made that the laws of induction follow of necessity from Ampère's forces and conservation is of too broad a nature. If we modify the statement, and say that the laws of induction are consistent with Ampère's actions, and with conservation, there will be nothing to be objected to. That this is not a mere difference of tweedledum and tweedledee may be easily seen from the history of the subject, if it is not sufficiently evident by itself. We may, indeed, from the existence of Ampère's forces, and a conviction of the truth of the conservation principle, conclude certainly that some other actions occur, but the principle merely asserts that energy is never lost, that energy put into a system from outside must necessarily be either stored up or make its appearance somewhere in some form or other; but what the form may be depends upon the mechanism, on the dynamical connections, and conservation does not tell us what they are, nor what will happen. There must be other information given.

(TO BE CONTINUED.)

Electric Lighting for Westminster.—A memorial has been addressed to the vestry of St. James's, Westminster, in favour of the granting of a provisional order to light a certain portion of the district by electric light to the Telegraph Construction and Maintenance Company, and not to the Edison Electric Light Company.

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CITY AND GUILDS OF LONDON INSTITUTE FOR THE ADVANCEMENT OF TECHNICAL EDUCATION.

TECHNOLOGICAL EXAMINATIONS, 1883.

22B.—ELECTRIC LIGHTING AND TRANSMISSION OF POWER.

Examiner, Prof. AYRTON, F.R.S.

Instructions.

This examination is for the purpose of ascertaining whether the candidate has intelligently studied the methods of constructing and using the machinery employed in the production and transmission of electric power, and whether he has endeavoured to ascertain the scientific reasons underlying the processes adopted.

The candidate must confine himself to one grade only, the ordinary, or honours, and must state at the top of his paper of answers which grade he has selected. He must not answer questions in more than one grade.

If he has already passed in this subject in the first division of the ordinary grade he must select his questions from those of the honours grade.

The number of the question must be placed before the answer in the worked paper.

Each candidate is supplied with a sheet of ruled squared paper to be used for plotting curves only.

Three hours allowed for this paper.

Ordinary, or Pass Grade.

[Candidates are not expected to answer more than six questions, but more may be attempted.]

1. What is meant by electromotive force? Distinguish between a voltameter and a voltmeter. A voltameter is joined up in series with an electro-magnet, and various currents are successively sent through the two instruments; compare the action in the voltameter with the force necessary to detach the armature of the electro-magnet for the various currents.

2. Without going into details as to how resistances are practically measured, explain accurately what is meant when it is said that one resistance is ten times as great as another.

3. Define an ohm, ampere, volt, coulomb, and farad. What current will 12 Daniell cells, arranged 4 in series and 3 in parallel, send through a galvanometer of 50 ohms resistance, shunted with a resistance of 10 ohms, if the cells have each 3 ohms resistance and the wire joining the battery with the galvanometer has a resistance of 5 ohms?

4. What is the principle of a dynamo? Explain in detail the construction of the dynamo with which you are best acquainted, describing the nature of the material (soft iron, cast iron, or steel, &c.) employed in each part, and give full sketches illustrating the mode of winding the coils, and the size and shape of each part of the machine, as well as the reasons for the method of manufacture employed.

5. Explain the difference between a "series" dynamo and a "shunt" dynamo, and give drawings showing the mode in which the wires are wound in each machine.

6. Distinguish between the electromotive force of a dynamo and the potential difference at its terminals. Explain how the electromotive force and the potential difference at the terminals vary with the external resistance—first, in a "series" dynamo, secondly, in a "shunt" dynamo.

7. What is meant by the "efficiency" of an incandescent lamp? Why does the efficiency increase with the current sent through it? State what practical results have been obtained connecting the efficiency of a carbon filament with its life. Give the "efficiencies" of the various incandescent lamps you are acquainted with when glowing with their normal currents.

8. What is the principle of a "speed indicator" and a "speed counter?" Give drawings.

9. Define a "watt." Give a drawing and description of a "watt meter."

10. What is meant by the "lead" given to the brushes in a dynamo? Show, with sketches, the lead that should be given in a dynamo, and in the same machine when run as a motor, and give your reasons. Explain how the lead must be adjusted for speed and for current, first, in a "series," secondly, in a "shunt" dynamo.

11. Give a table of the safe currents that may be sent through copper wires of various gauges. What percentage loss of potential is there when 50 amperes is sent through 100 yards of copper wire $\frac{1}{8}$th inch in diameter if the initial potential is 110 volts? A foot of copper wire $\frac{1}{1000}$th of an inch in diameter has about 10 ohms resistance at 0° C.

Honours Grade.

[Candidates are not expected to answer more than seven questions, but more may be attempted.]

1. What is meant by electromotive force? Distinguish between a voltameter and a voltmeter. A voltameter is joined up in series with an electro-magnet, and various currents are successively sent through the two instruments; compare the action in the voltameter with the force necessary to detach the armature of the electro-magnet for the various currents.

2. Without going into details as to how resistances are practically measured, explain accurately what is meant when it is said that one resistance is ten times as great as another.

3. Define an ohm, ampere, volt, coulomb, and farad. What current will 12 Daniell cells, arranged 4 in series and 3 in parallel, send through a galvanometer of 50 ohms resistance, shunted with a resistance of 10 ohms, if the cells have each 3 ohms resistance and the wire joining the battery with the galvanometer has a resistance of 5 ohms.

4. What is meant by the characteristic curve for a dynamo? Draw the curve for a series Gramme, and explain what practical use can be made of it. Draw the actual curve connecting the potential difference at the brushes of the shunt dynamo with which you are best acquainted, with the current flowing in the external circuit.

5. Explain the general principles of the methods that have been designed to keep the potential difference between electric mains constant and independent of the current required. Give full details of that one of the systems with which you are best acquainted.

6. Explain fully why the electromotive force in a dynamo run at constant speed falls off for increase of current after the current has reached a certain limit.

7. Describe fully with drawings the various methods that have been designed to cause an electro-motor to run at a constant speed, whatever work it may be doing.

8. A certain motor, in which the armature and field magnet have each a resistance of 0·1 ohm when run at 1,000 revolutions a minute, produces 1 horse-power when a current of 30 amperes flows through the motor, and a potential difference of 45 volts is maintained at its terminals. What should be the resistance of the armature and field magnet of the same motor, so that it will produce 1 horse-power when run at the same speed, and when a potential difference of 200 volts is maintained between its terminals, the efficiency of the motor remaining the same?

9. You are required to design and fit an electro-motor to a tramcar. Write out the advantages and disadvantages you see in the three following methods: (1) A rapidly turning motor attached to the ordinary tramcar wheels, with some speed-reducing gear; (2) a rapidly turning motor attached to a driving wheel of small diameter, without speed reducing gear; (3) a motor attached directly to the ordinary wheels and only turning as fast as they ordinarily do. Select that one of the methods which you consider the best, and give sketches of the exact way in which you would carry it out.

10. Write a short essay, showing what has been practically done in electric transmission of power, giving figures, &c., to show the amount of power transmitted, the efficiency obtained, the practical difficulties that have been met with, &c.

22C.—ELECTRICAL INSTRUMENT MAKING.

Instructions as for 22B.—Ordinary, or Pass Grade.

[Candidates are not expected to answer more than six questions, but more may be attempted.]

1. What is meant by electromotive force? Distinguish between a voltameter and a voltmeter. A voltameter is joined up in series with an electro-magnet and various currents are successively sent through the two instruments. Compare the action in the voltameter with the force necessary

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to detach the armature of the electro-magnet for the various currents.

2. Without going into details as to how resistances are practically measured, explain accurately what is meant when it is said that one resistance is ten times as great as another.

3. Define an ohm, ampere, volt, coulomb, and farad. What current will 12 Daniell cells, arranged 4 in series and 3 in parallel, send through a galvanometer of 50 ohms resistance, shunted with a resistance of 10 ohms, if the cells have each 3 ohms resistance and the wire joining the battery with the galvanometer has a resistance of 5 ohms?

4. Describe the best practical method for magnetising steel bar magnets so that they may be regularly magnetised.

5. What is meant by "calibrating" a galvanometer? Describe the various methods of calibrating that may be employed.

6. A foot of copper wire, $\frac{1}{1000}$th of an inch in diameter, has about 10 ohms resistance at 0°C; what then will be the resistance of a wire of No. 16 gauge (having about $\frac{1}{16}$th inch diameter) of the proper length to fill a bobbin, whose height inside the endcheeks is 3 inches, external diameter 2 inches, and the diameter of whose core is $\frac{3}{4}$ inch? How much will the resistance be altered if the temperature be raised to 20°C, and in which direction will it be altered?

7. Explain how the heat produced in a coil by a current passing through it is connected with its magnetic effect. A certain bobbin of wire through which a current is passed is found not to produce sufficient magnetic effect when the current is so strong as to heat it to a limit of safety. Is it possible by altering the gauge of wire employed to increase the magnetic effect without increasing the temperature of the coil?

8. You are desired to construct a glass Leyden jar with very high insulation; explain by means of sketches exactly how you would accomplish this. Give a sketch of an insulating stand with high insulation.

9. Give a drawing of a shunt box having high insulation. Prove what should be the resistance of three shunts, so that when respectively used, $\frac{1}{10}$th, $\frac{1}{100}$th, $\frac{1}{1000}$th of the total current passes through a galvanometer of 5,000 ohms resistance. What kind of wire would you use for the shunts; how would you wind it; and where would you place it to diminish the temperature error as much as possible?

10. What is meant by a "dead beat" galvanometer? Give a drawing of one. Describe in detail the construction of a galvanometer used to measure a a current absolutely.

Honours Grade.

[Candidates are not expected to answer more than seven questions, but more may be attempted.]

1. What is meant by electromotive force? Distinguish between a voltameter and a voltmeter. A voltameter is joined up in series with an electro-magnet and various currents are successively sent through the two instruments. Compare the action in the voltameter with the force necessary to detach the armature of the electro-magnet for the various currents.

2. Without going into details as to how resistances are practically measured, explain accurately what is meant when it is said that one resistance is ten times as great as another.

3. Define the ohm, ampere, volt, coulomb, and farad. What current will 12 Daniell cells, arranged 4 in series and 3 in parallel, send through a galvanometer of 50 ohms resistance, shunted with a resistance of 10 ohms, if the cells have each 3 ohms resistance and the wire joining the battery with the galvanometer has a resistance of 5 ohms?

4. Calculate the capacity in microfarads of a condenser composed of two plates, each $1\frac{1}{2}$ metre long, 65 centimetres wide, placed parallel to one another at a distance of 0·2 millimetre apart. 1 farad equals 9×10^{11} C.-G.-S. electrostatic units of capacity.

5. Describe in detail the construction of an artificial cable, and the methods you would employ for testing it.

6. What is the best method for preventing the bad effect of damp on resistance coils? In order to make a resistance box to measure anything from 1 to 10,000 ohms, what is the least number of coils that must be employed, and what are their respective resistances?

7. Explain in detail how an electromotive force can be measured absolutely by weighing.

8. An ebonite rod, 3 inches high, carrying a binding screw at the top, has to be fastened to a wooden board by a screw passing through the board. Show, by means of a sketch, what shape you would give to the ebonite rod to obtain the maximum insulation, and mention what is the fault usually made and which is especially to be guarded against in fixing the rod to the board.

9. What is the law connecting the strength of a straight electro-magnet with its length, the diameter of the core, the number of turns of wire and the current? Explain what are the limitations, and the reason of such limitations, in the use of your formula. Compare the strength of an electro-magnet when wrought iron, cast iron, and steel are respectively used for the core, other things remaining the same.

10. If the diameter of the coil of an electro-magnet is fixed, prove what is the best diameter to give to the iron core. Show whether the same rule holds if the diameter of the core be fixed, whilst that of the coil is variable.

ELECTRICAL MACHINES AND THE TRANSMISSION OF POWER.

(Translation.)

TO THE EDITOR OF THE ELECTRICIAN.

Sir: I do not know what answer my honoured antagonist, Mr. Kapp, will make to the letter which you were good enough to insert in *The Electrician* for May 19th last. I do not even know whether Mr. Kapp will deign to reply to this letter; but, in any case, I do not wish to delay any longer in expressing my gratitude for the kindness you have vouchsafed to my labours in the columns of your esteemed publication. In pursuance of this line of thought I cannot do better than demonstrate to you that the ideas I have put forward, and which you have thought to be of some interest, are not as baseless as has been stated. I will therefore justify the reception you have been good enough to accord to my two letters.

What appears to exasperate Mr. Kapp, whose authority in matters scientific I am fully cognisant of, is that I have been bold enough to presume that "it may perhaps be possible to use receivers without wire in the magnetic field that can be subject to induction." Now, the last number of *Engineering* mentions an electro-motor, patented by M. Immisch, of London, which is nothing more or less than a machine *without wire in the magnetic field that can be subject to induction*, and, moreover, seems to be a very good machine. The English have not got the name of being very unpractical people, and when they take out a patent it generally has its *raison d'être*. I conclude that I was not far from some such conception, and that you may perhaps have done good in giving it a place.

When I wrote my first letter of the 13th April, I evidently had no knowledge of this patent of M. Immisch's, which was only published in *Engineering* of the 18th May; further, the machine which I have made a study of does not resemble that of this inventor. It has been sufficient for me to show you that I have not been guilty of a joke, which would, in any case, be out of place in the columns of a scientific and widely circulated journal such as yours, in speaking of machines "*without wire in the magnetic field that can be subject to induction.*" [*Sans fil de l'induit, dans le champs magnétique.*]

Your translator has not yet succeeded in giving a perfect rendering of the sense of this phrase; however, it is comprehensible to those who do not wilfully misread it, and I again thank you for having translated my letter so well.

Perhaps I may be able at some future time to submit to you a complete description of the system of transmission that I have conceived; my labour can be examined by any competent persons, and if it is considered worth anything I shall endeavour to make it known in England.—Yours, &c.,

A. Bandsept,

May 26, 1883. 15, Chaussee de Wavre, Bruxelles.

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THE ELECTRICIAN.

TO CORRESPONDENTS.

All letters intended for insertion in THE ELECTRICIAN, *or containing questions, must be accompanied by the name and address of the writer, not necessarily for publication, but as a proof of good faith. No notice whatever will be taken of anonymous communications.*

All communications to be addressed to 396, Strand, London, W.C.

We cannot undertake to return drawings or manuscripts, and must, therefore, request Correspondents to keep copies.

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ANSWERS TO CORRESPONDENTS.

JOHN TOURTEL.—*Your letter and illustration will appear next week.*

G. MARTIN (Brighton).—*We can easily give you the names of half a dozen electric light firms, but it is hardly our province to supply you with the names of their managing directors. There are Messrs. Siemens, of 12, Queen Anne's-gate, S.W.; Crompton and Co., of Mansion House-buildings, E.C.; Swan Electric Light Company, St. Mildred's-court, Poultry, E.C.; Edison Electric Light Company, Coleman-street, E.C.; Telegraph Construction and Maintenance Company, Old Broad-street, E.C.; Woodhouse and Rawson, Queen Victoria-street, E.C.; Pilsen Joel and General Company, St. Stephen's-chambers, Telegraph-street, E.C.; Hammond and Co., 110, Cannon-street, E.C.*

R. M. OATES.—*The address is 51, Rue Vivienne, Paris. The price, one franc.*

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ELECTRIC LIGHT FOR MINES.

This is not the best season of the year for attracting the attention of the general public to the subject of explosions in mines. The atmospheric condition is equable and comparatively safe; there are no startling announcements of colliery explosions, with their ghastly tale of figures, which at another time of the year become almost monotonous with daily repetition. But, for that very reason, this is the time for making an effort to prevent their recurrence, to try experiments which may now be conducted with safety, but which, later on, it would be impossible, or at all events dangerous, to attempt. On these grounds, therefore, we would earnestly re-invite the attention, not of the public so much as of electricians, to this most important subject—a subject which will assuredly bring both fame and profit to him who may be fortunate enough to dispose of it satisfactorily.

We say re-invite their attention, for there was no lack of it when popular favour first warmly espoused the electric light. Its applicability to the lighting of coal mines was at once fully appreciated by those who were scientifically engaged in the work, and we heard of several isolated attempts to establish its practicability. From time to time we have notified the introduction of the light into a mine here and there, but, for some cause yet to be explained, the experiments have not been so numerous as we had hoped and expected. Some discouragement probably arose from the supposed necessity for using currents of such a strength and character as to be of themselves dangerous. The successful application of perfectly safe currents above ground for lighting purposes has removed this hindrance to the lighting of underground spaces, and we see no present reason why a fresh effort should not now be made on the part of electric light promoters to include the proprietors of mines among their best customers.

The immediate cause of the terrible catastrophes to which all toilers in mines—especially, of course, in coal mines—are periodically exposed is usually a subject of conjecture, the only witnesses who could afford positive testimony having been launched beyond the reach of all questioning. But there is little doubt that failure of the safety lamp, or negligence in its use, is at the bottom of most of the accidents traceable to the explosion of fire damp. Davy's invention was, undoubtedly, one of the most beneficent contributions to the welfare of mankind that science has ever conferred; but in an indirect way it has not improbably led to greater carelessness in the matter of ventilation, and therefore to greater risks in the employment of any sort of light where carburetted hydrogen is apt to collect. It would, we suppose, be almost treason to hint at the possibility of the lamp itself, under certain conditions, being capable of igniting an explosive gas; but so many accidents do occur notwithstanding the obligatory use of the safety lamp that we are unable always to attribute them to the culpable negligence of the men most profoundly interested in using it with care. The lamp is not considered quite safe, we believe, when an explosive mixture passes through it with great rapidity—a condition of things that may be brought about at any moment, for example, by the accidental rupture of a partition dividing two adjoining galleries the atmospheres of which are at different temperatures. One of its merits is that it is extinguished when an atmosphere is entered which would be fatal to the bearer, thus giving him timely warning of his danger. But here the temptation arises to obtain a light even at the risk of an explosion, for though the platinum wire which encoils the flame continues to give off a faint glow after the lamp itself is put out, the man is soon left in darkness. He wants to resume work with natural, and sometimes with incautious, haste, the consequences of which are only too often disastrous.

Now, what is wanted under these circumstances is an adequate illumination of the mine in a manner that the carrying of lamps would be rendered superfluous, and explosions from causes directly or indirectly attributable to their use impossible. The electric light, it seems to us, is just the thing to supply this very grave defect. Its fitness is indeed so obvious that we need not enlarge upon it here. With incandescent lamps duly protected, wires properly encased, and

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currents powerless to do mischief, there is no reason why the shafts and galleries of every mine should not be as well lighted as any factory or workshop after dark. Some experiments would, of course, have to be made, owing to the novel conditions under which installations of this kind must be carried out; but the nature of the difficulties to be overcome is pretty well understood, and this, we say, is the time of the year when the attempt to overcome them can best be made.

The question of expense ought not, in a case of this sort, to stand in the way of so great an improvement. There is here no competition with gas to be considered; the electric light would present itself on its own merits without a rival, and those merits are of the highest possible kind where the hardships of human labour and the danger to human life can be so greatly mitigated by its means. And this observation applies to all classes of mines, whether collieries or not, for undoubtedly miners in general would pursue their callings under greatly improved conditions, and their output would consequently be proportionally augmented if they were allowed the inestimable privilege of working in an atmosphere thoroughly well lighted and at the same time thoroughly safe.

CORRESPONDENCE.

TESTING LIGHTNING CONDUCTORS.

TO THE EDITOR OF THE ELECTRICIAN.

Sir: I think it is evident from the diagram and letter of "T.L.P." in your paper last week that he has made three errors in testing his lightning conductors.

1. He should have used the same lengths or resistances for his two No. 16 B.W.G. leading wires, or have noted the difference in their resistance before soldering them to his lightning conductor (C) and main water earth (M.W.), and connecting them respectively to his Wheatstone bridge and resistance-box (R). Any difference in the resistance of these two leading wires must appear as a + or — error in his results unless allowed for or cancelled.

2. He says he tested with three Leclanché cells. Now, it is well known that such cells polarise or "run down" very quickly when in circuit with such low resistances as he had to deal with, and thereby tend to give unstable results. He will find good Daniell cells of low resistance, having well amalgamated zinc plates placed in a saturated solution of sulphate of zinc, and clean copper plates in a saturated solution of sulphate of copper, with thin porous diaphragms between the zinc and copper, much better for his purpose; but even with these he should not keep his battery on for a longer time than is just necessary to get a balance.

3. Owing to his employing for the one earth a *leaden* pipe and for the other a *cast-iron* one, there must have been present a current from the one to the other, which current would affect his galvanometer when it was brought into circuit, and act with or against his battery current according to circumstances. With such an arrangement of earths it is necessary to balance to the earth current (or false zero as it is sometimes termed), and not to the zero of galvanometer, and to take the mean of readings with + and — or alternate currents before perfectly uniform results can be obtained, in precisely the same way as that of testing a submarine cable for copper resistance.

If "T.L.P." has had the copper band from his lightning conductor fixed in the way mentioned to the cast-iron pipe (S.W.) for some time with no further precautions, and if it is in a damp or wet situation, would he kindly look at it now and say whether he observes any eating away of the cast-iron pipe near the junction. I have seen the whole of the sheathing from the heavy shore end of a submarine cable eaten away in a few months by a similar mode of attachment. Perhaps he will kindly repeat his tests, taking note of the three above-mentioned possibilities of error, and give us his results through the columns of your valuable paper.

The accidents from lightning last week have been serious and numerous, and such results as "T.L.P." has given us are valuable, more especially owing to their scarcity. I have tested several lightning conductors, using two or three different earths for the testing battery, with a view of obtaining the *absolute* resistance in ohms to earth of the lightning conductor, and not the resistance between its earth and that of any one of the battery earths, but I never got such low results as "T.L.P.'s" ·31 and ·46 ohm.—Yours, &c.,

Glasgow, 12th June, 1883. A. J.

THE GRAMME RING.

TO THE EDITOR OF THE ELECTRICIAN.

Sir: The remarks made by Mr. Mordey in the earlier part of his letter of last week need no answer. In the latter part he credits me with an experiment I did not perform as concerns the Schukert machine. When he added the two remaining magnets he not only doubled his lines of magnetic force, but he also (according to his theory) doubled the wires cutting those lines. Of course, when he added his two remaining magnets, he should have *kept his total magnetism constant*. I am surprised he did not obtain a much greater increase than he reports.

As in all proofs of the kind, "quantitative" proof is always open to objection; but as a qualitative proof of the true action of the Gramme ring, that of Marcel Deprez, with which I have only just become acquainted, is conclusive to the extreme. I append the translation as nearly as may be:—

"Take a ring of the Gramme type, surround it with a cylinder of iron, and put it in motion; we present then a a magnet successively outside of the cylinder of iron and inside, in the two cases induction produces itself sensibly with the same intensity; to operate with precision, account should be taken of the difference of distance. The experiment has not been pushed to this point, but such as it is there results from it that the covering of iron does not constitute a screen."

The same number of *La Lumière Electrique* (Feb. 24, 1883) contains some account of further indirectly conclusive experiments by M. J. Stefan on the "Action of Iron as a Magnetic Screen." M. Stefan's experiments also appear in the *Annalen der Physik u. Chemie* (Wiedemann's) Dec. 2, 1882.—Yours, &c., Paget Higgs.

"INFORMATION WANTED."—MEDICAL ELECTRICITY.

TO THE EDITOR OF THE ELECTRICIAN.

Sir: While admitting the correctness of Mr. Sprague's remarks relative to magnets, I should like to call "Neuralgia's" attention to the medical effects of passing an electric current, continuous or intermittent, through an organ or part of the body which is a seat of disease.

Having both felt the effects of and applied to patients with very beneficial results an interrupted current of moderate intensity, I shall be pleased to furnish him with the necessary information for procuring suitable apparatus.

Though, as Mr. Sprague says, magnets "can do no work unless an external supply of energy is provided," yet when energy (electrical) from the consumption of zinc, or from mechanical force, is expended in overcoming the resistance of the tissues of the body, and stimulating nervous action both sensory and motor, it is not difficult to conceive a definite physical effect. And with those of your readers who have had some practical experience in electric lighting it will be more than a matter of conception. In these cases, as in the more common of shocks from the coils exhibited in fairs, market places, &c., the results are as likely to be injurious as beneficial.

But with coils and batteries properly and scientifically constructed to do their work, the writer has no doubts as to the immense amount of good that may be done in removing

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diseases such as rheumatism, which result from an accumulation of waste products not thrown off, as in a healthy man they are, by the lungs, the kidneys, and the skin.

I fear I should be trespassing on your valuable space if I attempted to demonstrate the physiological actions above suggested.—Yours, &c.,

A. W. BENNETT,

Nottingham. Queen's Medalist, Animal Physiology.

THE PASSAGE OF ELECTRICITY THROUGH GLASS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In your current volume, page 27, there is a short notice of experiments by M. Foussereau on the passage of electricity through glass. In a recent number of a contemporary of yours there was also a notice of these experiments of M. Foussereau. The two notices do not agree, but, while they do not contradict one another, they show that there is much valuable information to be obtained concerning the nature of electricity if the particulars of these experiments were published. They corroborate the accuracy of the experiments of mine which you published some time ago, whereby I proved that the theory of the Leyden jar depends on a portion of the electricity passing through the glass of the jar. I hope that you may be able to give the details of M. Foussereau's experiments.—Yours, &c., JAMES JOHNSTONE.

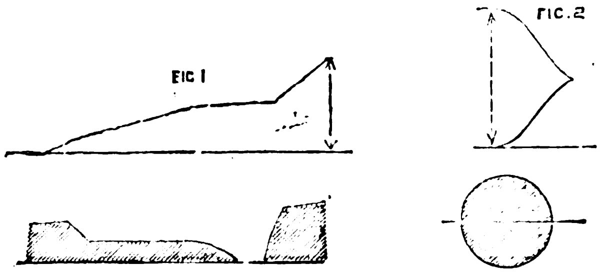
8, Dalhousie-terrace, Edinburgh. June 2, 1883.

ON METERS FOR POWER AND ELECTRICITY.*

BY MR. C. VERNON BOYS.

The subject of this evening's discourse—"Meters for Power and Electricity"—is unfortunately, from a lecturer's point of view, one of extreme difficulty, for it is impossible to fully describe any single instrument of the class without diving into technical and mathematical niceties which this audience might well consider more scientific than entertaining. If then, in my endeavour to explain these instruments and the purposes which they are intended to fulfil, in language as simple and as untechnical as possible, I am not as successful as you have a right to expect, I must ask you to lay some of the blame on my subject and not all on myself.

I shall at once explain what I mean by the term "meter," and I shall take the flow of water in a trough as an illustration of my meaning. If we hang in a trough a weighted board, then, when the water flows past it, the board will be pushed back; when the current of water is strong, the board will be pushed back a long way; when the current is less it will not be pushed so far; when the water runs the other way the board will be pushed the other way. So by observing the position of the board, we can tell how strong the current of water is at any time. Now, suppose we wish to know, not how strong the current of water is at this time or at that, but how much water altogether has passed through the trough during any time, as, for instance, one hour. Then, if we have no better instrument than the weighted board, it will be necessary to observe its position continuously to keep an exact record of the corresponding rates at which the water is passing every minute, or better every second, and to add up all the values obtained. This would, of course, be a very troublesome process. There is another kind of instrument which may be used to measure the flow of the water—a paddle-wheel or screw. When the water is flowing rapidly the wheel will turn rapidly; when slowly, the wheel will turn slowly; and when the water flows the other way, the wheel will turn the other way, so that if we observe how fast the wheel is turning we can tell how fast the water is flowing. If, now, we wish to know how much water altogether has passed through the trough, the number of turns of the wheel, which may be shown by a counter, will at once tell us. There are therefore, in the case of water, two kinds of instruments, one which measures at a time, and the other during a time. The term meter should be confined to instruments of the second class only. As with water so with electricity, there are two kinds of measuring instruments, one of which, the galvanometer, may be taken as a type, which shows by the position of a magnet how strong a current of electricity is at a time, and the other which shows how much electricity has passed during any time. Of the first, which are well understood, I shall say nothing; the second, the new electric meters and the corresponding meters for power, are what I have to speak of to-night. It is hardly necessary for me to mention the object of making electric meters. Every one who has had to pay his gas bill once a quarter probably quite appreciates what the electric meters are going to do, and why they are at the present time attracting so much attention. So soon as you have electricity laid on in your houses, as gas and water are laid on now, so soon will a meter of some sort be necessary, in order that the companies which supply the electricity may be able to make out their quarterly bills, and refer complaining customers to the faithful indications of their extravagance in the mysterious cupboard in which the motor is placed. The urgent necessity for a good meter has called such a host of inventors into the field, that a complete account of their labours is more than any one could hope to give in an hour. Since I am one of this host, I hardly like to pick out those inventions which I consider of value. I cannot describe all, I cannot act as a judge and say these only are worthy of your attention, and I do not think I should be acting fairly if I were to describe my own instruments only and ignore those of every one else. The only way I see out of the difficulty is to speak more particularly about my own work in this direction, and to speak generally on the work of others.



I must now ask you to give your attention for a few minutes to a little abstract geometry. We may represent any changing quantity, as the strength of an electrical current, by a crooked line (Fig. 1). For this purpose we must draw a straight line to represent time, and make the distance of each point of the crooked line above the straight line a measure of the strength of the current at the corresponding time. The size of the figure will then measure the quantity of electricity that has passed, for the stronger the current is the taller the figure will be, and the longer it lasts the longer the figure will be, either cause makes both the quantity of electricity and the size of the figure greater, and in the same proportion, so the one is a measure of the other. Now it is not an easy thing to measure the size of a figure, the distance round it tells nothing; there is, however, a geometrical method by which its size may be found. Draw another line, with a great steepness where the figure is tall, and with a less steepness where the height is less, and with no steepness or horizontal where the figure has no height. If this is done accurately the height to which the new line reaches will measure the size of the figure first drawn, for the taller the figure is the steeper the hill will be, the longer the figure the longer the hill; either cause makes both the size of the figure and the height of the hill greater, and, in the same proportion, so the one is a measure of the other; and so, moreover, is the height of the hill, which can be measured by scale, a measure of the quantity of electricity that has passed.

The first instrument that I made, which I have called a "cart" integrator, is a machine which, if the lower figure is traced out, will describe the upper. I will trace a circle. The instrument follows the curious bracket-shaped line that I

* Lecture delivered at the Royal Institution of Great Britain.

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have made sufficiently black to be seen at a distance (Fig. 2). The height of the new line measures the size of the circle. The instrument has squared the circle. This machine is a thing of mainly theoretical interest. My only object in showing it is to explain the means by which I have developed a practical and automatic instrument, of which I shall speak presently. The guiding principle in the cart integrator is a little three-wheeled cart, whose front wheel is controlled by the machine. This, of course, is invisible at a distance, and therefore I have here a large front wheel alone. On moving this along the table any twisting of its direction instantly causes it to deviate from its straight path. Now, suppose I do not let it deviate, but compel it to go straight, then at once a great strain is put upon the table, which is urged the other way. If the table can move it will instantly do so. A table on rollers is inconvenient as an instrument, let us, therefore, turn it into a roller (Fig. 3), then on moving the wheel along it the roller will turn, and the amount by which it turns will correspond to the height of the second figure drawn by the cart integrator. If, therefore, the wheel is inclined by a magnet under the influence of an electric current, or by any other cause, the whole amount of which we wish to know, then the number of turns of the roller will tell us this amount; or to go back to our water analogy, if we had the weighted board to show current strength, and had not the paddle-wheel to show total quantity, we might use the board to incline a disc in contact with a roller, and then drag the roller steadily along by clock work. The number of turns of the roller would give the quantity of water. Instruments that will thus add up continuously indications at a time, and so find amounts during a time, are called integrators. The most important application

FIG. 3

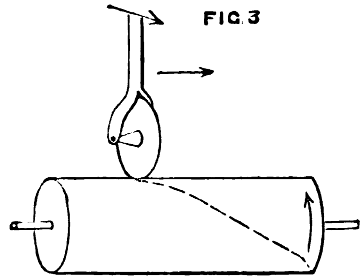
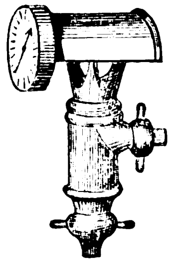


FIG. 4



that I have made at present of the integrator described is what I have called an engine-power meter. The instrument is on the table, but as it is far too small to be seen at a distance, I have arranged a large model to illustrate its action. The object of this machine is to measure how much work an engine has done during any time, and show the r sult on a dial, so that a workman may read it off at once, without having to make any calculations (Fig. 4).

Before I can explain how work is measured, perhaps I had better say a few words about the meaning of the word "work." Work is done when pressure overcomes resistance, producing motion. Neither motion nor pressure alone is work. The two factors, pressure and motion, must occur together. The work done is found by multiplying the pressure by the distance moved. In an engine steam pushes the piston first one way, then the other, overcomes resistance, and does work. To find this we must multiply the pressure by the motion at every instant, and add all the products together. This is what the engine-power meter does, and it shows the continuously growing result on a dial. When the piston moves it drags the cylinder along; where the steam presses the wheel is inclined. Neither action alone causes the cylinder to turn, but when they occur together the cylinder turns, and the number of turns registered on a dial shows with mathematical accuracy how much work has been done.

In the steam engine work is done in an alternating manner, and it so happens that this alternating action exactly suits the integrator. Suppose, however, that the action, whatever it may be, which we wish to estimate is of a continuous kind, such, for instance, as the continuous passage of an electric current. Then, if by means of any device we can suitably incline the wheel, so long as we keep pushing the cylinder along, so long will its rotation measure and indicate the result; but there must come a time when the end of the cylinder is reached. If then we drag it back again, instead of going on adding up, it will begin to take off from the result, and the hands on the dial will go backwards, which is clearly wrong. So long as the current continues, so long must the hands on the dial turn in one direction. This effect is obtained in the instrument now on the table, the electric energy meter, in this way. Clockwork causes the cylinder to travel backwards and forwards by means of what is called a mangle motion, but instead of moving always in contact with one wheel, the cylinder goes forward in contact with one and back in contact with another on its opposite side. In this instrument the inclination of the wheels is effected by an arrangement of coils of wire, the main current passing through two fixed concentric solenoids, and a shunt current through a great length of fine wire on a movable solenoid, hanging in the space between the others. The movable portion has an equal number of turns in opposite directions, and is therefore unaffected by magnets held near it. The effect of this arrangement is that the energy of the current—that is, the quantity multiplied by the force driving it, or the electrical equivalent of mechanical power—is measured by the slope of the wheels, and the amount of work done by the current during any time, by the number of turns of the cylinner, which is registered on a dial. Professors Ayrton and Perry have devised an instrument which is intended to show the same thing. They make use of a clock, and cause it to go too fast or too slow by the action of the main on the shunt current; the amount of wrongness of the clock, and not the time shown, is said to measure the work done by the current. The method of measuring the electricity by the work it has done is one which has been proposed to enable the electrical companies to make out their bills.

The other method is to measure the amount of electricity that has passed without regard to the work done. There are three lines on which inventors have worked for this purpose. The first, which has been used in every laboratory ever since electricity has been understood, is the chemical method. When electricity passes through a salt solution it carries metal with it, and deposits it on the plate by which the electricity leaves the liquid. The amount of metal deposited is a measure of the quantity of electricity. Mr. Sprague and Mr. Edison have adopted this method; but as it is impossible to allow the whole of a strong current to pass through a liquid, the current is divided; a small proportion only is allowed to pass through. Provided that the proportion does not vary, and that the metal never has any motions on its own account, the increase in the weight of one of the metal plates measures the quantity of electricity.

The next method depends on the use of some sort of integrating machine, and this being the most obvious method, has been attempted by a large number of inventors. Any machine of this kind is sure to go, and is sure to indicate something, which will be more nearly a measure of the electricity as the skill of the inventor is greater.

Meters for electricity of the third class are dynamical in their action, and I believe that what I have called the vibrating meter was the first of its class. It is well known that a current passing round iron makes it magnetic. The force which such a magnet exerts is greater when the current is greater, but it is not simply proportional. If the current is twice or three times as strong, the force is four times or nine times as great, or generally, the force is proportional to the square of the current. Again, when a body vibrates under the influence of a controlling force, as a pendulum under the influence of gravity, four times as much force is necessary to make it vibrate twice as fast, and nine times to make it vibrate three times as fast; or generally, the square of the number measures the force. I will illustrate this by a model. Here are two sticks nicely balanced on points, and drawn into a middle position by tapes to which weights may be hung (Fig. 5). They are identical in every respect. I will now hang a 1lb. weight to each tape, and let the pieces of wood swing. They keep time together absolutely. I will now put 2lb. on one tape. It is clear that the corresponding stick is

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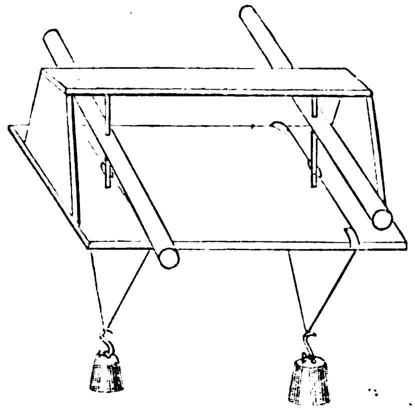
going faster, but certainly not twice as fast. I will now hang on 4lb. One stick is going at exactly twice the pace of the other. To make one go three times as fast it is obviously useless to put on 3lb., for it takes four to make it go twice as fast. I will hang on 9lb. One now goes exactly three times as fast as the other. I will now put 4lb. on the first, and leave the 9lb. on the second; the first goes twice while the second goes three times. If instead of a weight we use electro-magnetic force to control the vibrations of a body, then twice the current produces four times the force, four times the force produces twice the rate; three times the current produces nine times the force, nine times the force produces three times the rate, and so on; or the rate is directly proportional to the current strength. There is on the table a working meter made on this principle. I allow the current that passes through to pass also through a galvanometer of special construction, so that you can tell by the position of a spot of light on a scale the strength of the current. At the present time there is no current; the light is on the zero of the scale; the meter is at rest. I now allow a current to pass from a battery of the new Faure-Sellon-Volckmar cells which the Storage Company have kindly lent me for this occasion. The light moves through one division on the scale, and the meter has started. I will ask you to observe its rate of vibration. I will now double the current. This is indicated by the light moving to the end of the second division on the scale; the meter vibrates twice as fast. Now the current is three times as strong, now four times, and so on. You will observe that the position of the

FIG 5



spot of light and the rate of vibration always correspond. Every vibration of the meter corresponds to a definite quantity of electricity, and causes a hand on a dial to move on one step. By looking at the dial we can see how many vibrations there have been, and therefore how much electricity has passed. Just as the vibrating sticks in the model in time come to rest, so the vibrating part of the meter would in time do the same, if it were not kept going by an impulse automatically given to it when required. Also, just as the vibrating sticks can be timed to one another by sliding weights along them, so the vibrating electric meters can be regulated to one another so that all shall indicate the same value for the same current, by changing the position or weight of the bobs attached to the vibrating arm. The other meter of this class, Dr. Hopkinson's, depends on the fact that centrifugal force is proportional to the square of the angular velocity. He therefore allows a little motor to drive a shaft faster and faster, until centrifugal force overcomes electro-magnetic attraction, when the action of the motor ceases. The number of turns of the motor is a measure of the quantity of electricity that has passed.

I will now pass on to the measurement of power transmitted by belting. The transmission of power by a strap is familiar to every one in a treadle sewing machine or an ordinary lathe. The driving force depends on the difference in the tightness of the two sides of the belt, and the power transmitted is equal to this difference multiplied by the speed; a power meter must, therefore, solve this problem—it must substract the tightness of one side from the tightness of the other side, multiply the difference by the speed at every instant, and add all the products together, continuously representing the growing amount on a dial. I shall now show for the first time an instrument that I have devised, that will do all this in the simplest manner (Fig. 6). I have here two wheels connected by a driving band of india rubber, round which I have tied every few inches a piece of white silk ribbon. I shall turn one a little way, and hold the other. The driving force is indicated by a difference of stretching, the pieces of silk are much further apart on the tight side than they are on the loose. I shall now turn the handle, and cause the wheels to revolve; the motion of the band is visible to all. The india rubber is travelling faster on the tight side than on the loose side, nearly twice as fast; this must be so, for as there is less material on the tight side than on the loose, there would be a gradual accumulation of the india rubber round the driven pulley, if they travelled at the same speed; since there is no accumulation, the tight side must travel the fastest. Now it may be shown mathematically that the difference in the speeds is proportional both to the actual speed and to the driving strain; it is, therefore, a measure of the power or work being transmitted, and the difference in the distance travelled is a measure of the work done. I have here a working machine which shows directly on a dial the amount of work done; this I will show in action directly. Instead of india rubber, elastic steel is used. Since the driving pulley has the velocity of the tight side, and the driven of the loose side of the belt, the difference in the number of their turns, if they are of equal size, will measure the work. This difference I measure by differential gearing which actuates a hand on a dial. I may turn the handle as fast as I please; the index does not move, for no work is being done. I may hold the wheel, and produce a great driving strain; again the index remains at rest, for no work

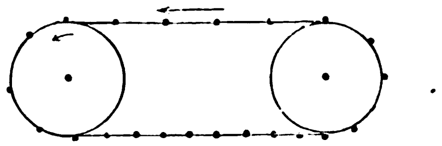


FIG. 6.

is being done. I now turn the handle quickly, and lightly touch the driven wheel with my finger. The resistance, small though it is, has to be overcome; a minute amount of work is being done, the index creeps round gently. I will now put more pressure on my finger, more work is being done, the index is moving faster; whether I increase the speed or the resistance the index turns faster; its rate of motion measures the power, and the distance it has moved, or the number of turns, measures the work done. That this is so I will show by an experiment. I will wind up in front of a scale a 7lb. weight; the hand has turned one-third round. I will now wind a 28lb. weight up the same height; the hand has turned four-thirds of a turn. There are other points of a practical nature with regard to this invention which I cannot now describe.

There is one other class of instruments which I have developed of which time will let me say very little. The object of this class of instruments is to divide the speed with which two registrations are being effected, and continuously record the quotient. In the instrument on the table two iron cones are caused to rotate in time with the registrations; a magnetised steel reel hangs on below. This reel turns about, and runs up or down the cones until it finds a place at which it can roll at ease. Its position at once indicates the ratio of the speeds which will be efficiency, horse-power per hour, or one thing in terms of another. Just as the integrators are derived from the steering of an ordinary bicycle, so this instrument is derived from the double steering of the "Otto" bicycle. Though I am afraid that I have not succeeded in the short time at my disposal in making clear all the points on which I have touched, yet I hope that I have done something to remove the very prevalent opinion that meters for power and electricity do not exist.

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PRACTICAL TELEPHONY.—(Continued from page 65.)

The Arrangement for Two or more Private Lines and Exchange Line in One Office, the Private Wires to be unable to Speak through to the Exchange.—The latter wires are connected to annunciators and the exchange wire to jack cord can be connected direct to the instrument as shown by the dotted line.

The Arrangement Adopted to Join a House and Church, &c., so that Subscribers have nothing to do but

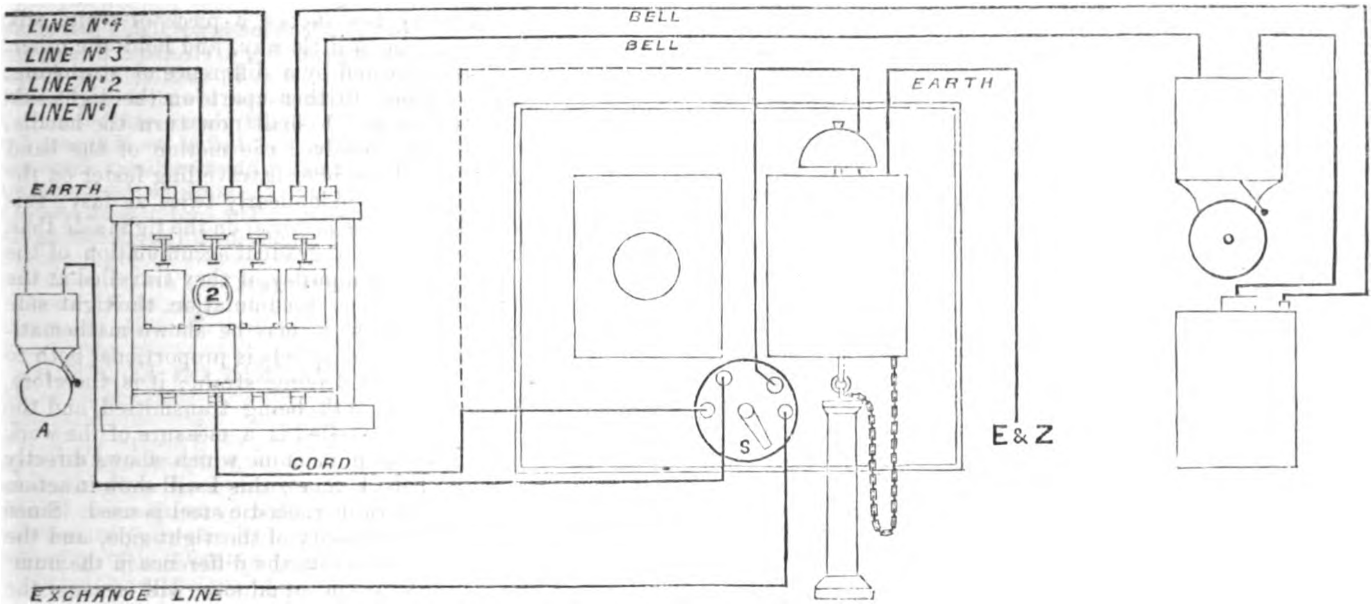

Fig. 17

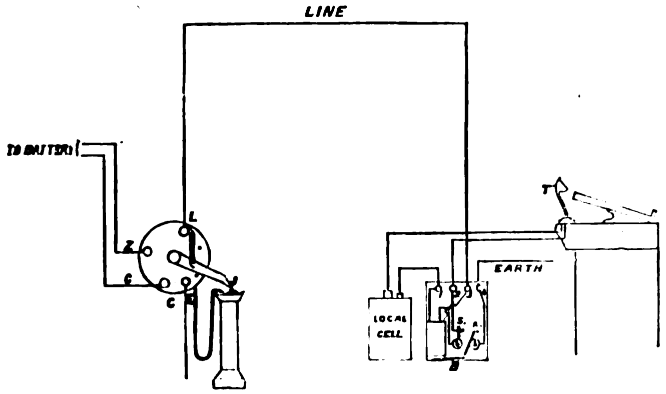

Fig. 18.

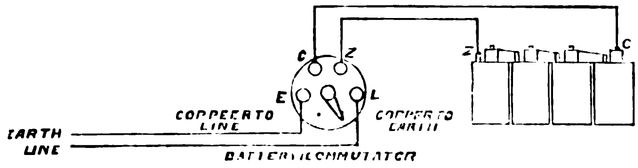

Fig. 20.

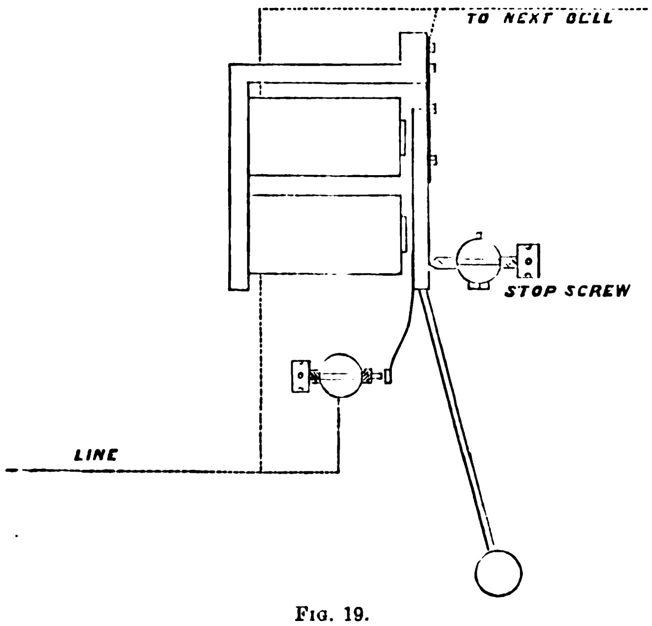

Fig. 19.

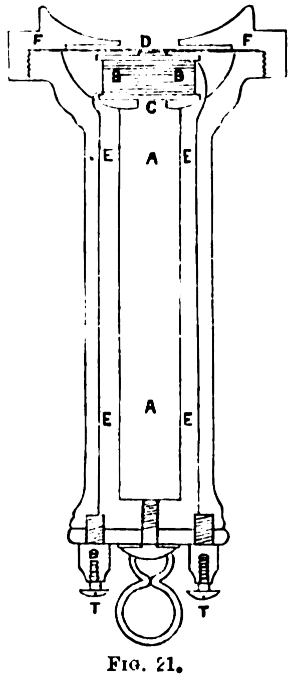

Fig. 21.

switch, as shown in Fig. 17. In the case where there is no exchange wire, or the private lines *may* be put through to exchange, the switch S and bell A will not be required, and the

to Unhook or Replace the Telephone, the Local Circuit of the Transmitter being Closed and Broken by these Movements alone, will be seen from Fig. 18. which shows the

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necessary apparatus and connections. C is a spring switch, B a case containing a polarised relay and induction coil. The action is as follows:—When the telephone is taken off the hook, a momentary current is sent to line, entering B at terminal 3, passing through secondary of coil, coils *t t* of polarised relay (which causes the arm A to move over and come in contact with S), terminal 4 to earth.

The primary circuit is as follows:—From the carbon of local cell to T, terminal 2, microphone contact S A, now closed, primary coil, terminal 1, and zinc of local cell. The transmitter is then in action.

When the telephone is hung up a momentary current is sent to line in the reverse directon to that first mentioned. This causes the arm A to leave the contact S, and thus break the primary circuit. No current is passing to line from the switch battery except during the time the telephone is being unhooked or hung up.

To Join Three Stations on One Line.—All the switch bells should be made to make and break contact, as shown at Fig. 19. The stations at each end of the line are connected as usual. The line is then looped into the centre station, one end being connected to terminal L, and the other end being connected to terminal E, instead of that terminal being connected to earth as usual. The zinc of battery must be connected to terminal E. Three stations may also be connected on what is practically one line by the use of the switch as shown in Figs. 14, 15, and 16 (page 64).

Battery Commutator.—This is the same form of switch as illustrated in Figs. 10, 11, 12 (page 64). The sketch, Fig. 20, explains itself.

The Telephone.—The form of Professor Bell's instrument used in this country is shown in section in Fig. 21. A is the magnet, TT terminals, B coil of fine wire, C pole piece, D diaphragm, E ebonite case, F screw cap of same. The action of the telephone depends on the well-known principle that when a coil of insulated wire is placed on the end of a permanent magnet, or its soft iron pole piece, any movement to or from the pole piece of an iron armature induces a current in the coil of wire. The armature is represented by the diaphragm D. To enable the telephone to reproduce speech an undulatory current must be employed, *i.e.*, a current that, so to speak, waves above and below a certain strength. This current may be either constant in one direction or alternating. The number of times per second that the diaphragm of a telephone vibrates determines the pitch, the loudness of the sounds produced depends on the extent of the vibrations. If the diaphragm be spoken against it vibrates in unison with the voice, and as the diaphragm is the armature of the magnet, corresponding undulating currents are generated in the coil of wire surrounding the magnet. When the instrument is connected up for use, the currents pass to line and into the coil of the receiving telephone, causing the magnetism of its magnet to be strengthened and weakened. The diaphragm approaches and recedes from the pole piece in unison with the diaphragm of the sending telephone, and this vibration acting on the air conveys to the ear a repetition of the words spoken into the sending telephone, but very much reduced in loudness. In practice, however, the sounds received are found to be too weak for practical purposes, and until battery transmitters came into use the application of the telephone was very limited. It is now, therefore, the universal practice to employ battery transmitters, which will be referred to further on.

The Adjustment of the Telephone.—In some of those first made the magnet was cemented into the ebonite cases by means of paraffin wax, pieces of which constantly chipped off, and got between the diaphragm and the pole piece. No allowance being made for their presence, the articulation was much deadened, or stopped altogether. Sometimes, again, the paraffin would be melted by heat, and run down between the diaphragm and pole piece, cementing the whole together. Some precaution was necessary to prevent these faults, and the writer advises all inspectors who have to deal with such instruments to provide discs of tissue paper an eighth of an inch larger in diameter than the opening of the bell in the telephone, with a hole in the centre three-quarters of an inch in diameter. Have them well gummed all over, and keep a supply at hand. To apply these discs, wet the gum on one of them, and stick it on the coil as central as possible. Press the outside edge down into the bell, so that it will not touch the diaphragm at any part, replace the diaphragm and cap, and the fault referred to will not occur in future. If it is found necessary to remove the paper at any time another can readily be put on. The manufacturers have, however, discontinued the use of wax, and a hard varnish is used instead, so that in the newer instruments these faults are not so liable to occur. Foreign particles are sometimes in the improved instrument to be found in the case, but the use of the gummed tissue paper provides the remedy. Be sure that the coil is firm upon the pole piece, or it may at times slide up and touch the diaphragm. The diaphragm D should be as close to the piece C as possible without touching, and the screw cap should be screwed down lightly. If the diaphragm is tightly fixed the articulation is much impaired. The diaphragm should not be buckled or bent in any way, or it is useless trying to get good results. If it cannot be readily set flat change it at once.

Although the coil wire in the telephone is not liable to become broken, it may become so at times, owing to electrical discharges from the line passing through it when in circuit; it is therefore advisable, when tracing a fault, to test it with a battery. If in good order a sharp click will be heard when contact is made; if none is heard, the instrument had better be returned for repairs. This test should be made with wire direct into the telephone terminals, and not through the cord, as the fault may exist in that and not in the telephone. The cord may afterwards be tested with the instrument attached if the telephone is found O K.

(TO BE CONTINUED.)

PROFESSOR FLEEMING JENKIN ON ELECTRIC LIGHTING.

The following is the first portion of a report by Professor F. Jenkin, F.R.S., on behalf of certain local authorities in respect of provisional orders promoted by companies. It will be seen that many of Professor Jenkin's suggestions are similar to the modifications adopted by the Board of Trade. This report was made at the end of January last:—

I.—Efficiency of Supply.

(*a*.) *Continuity of Supply.*—The undertakers do not propose to give a *continuous* supply—they reserve the right of interrupting the supply of electricity (s. 21 *f*) during certain intervals in the daytime. These intervals are, it is said, not on the whole to exceed *two hours* per diem.

It is obvious that the undertakers mean to avail themselves of this privilege, for they propose that the interruptions shall occur at *stated hours*, but they stipulate that this interruption may be allowed occasionally at other hours. They further propose to cut off the electricity during the greater part of each Sunday.

Long before the 21 years have expired for which the order will remain in force I am of opinion that in whole quarters of the town electrical lighting will have entirely superseded gas in private houses—that houses will have been built in which no gas pipe will be found. I am further of opinion that the supply of electricity for motors will have become an essential part of the economy of the city. Under these circumstances the power to cut off the supply of electricity habitually for two hours, and occasionally with no warning and no penalty, would inflict intolerable inconvenience and loss. The interruption might even be dangerous to life. Under these circumstances I am of opinion that no provisional order should be sanctioned which does not provide for a continuous supply of electricity, which shall not be interrupted except in case of *force majeure*. I see no reasons for permitting interruption in the case of electricity which do not apply with equal force to gas and water. I would from the outset oppose any attempt on the part of the companies to force consumers to adopt expensive and troublesome storage batteries to play the part which cisterns play in the case of water. Interruptions for the purpose of testing are quite unnecessary until there is some *primâ facie* ground for believing that defects exist; then notice of the intention to test should be served on every customer, and the hour chosen when least inconvenience would be caused.

As a possible concession I would perhaps allow the undertakers to interrupt the supply for a short period daily, during perhaps the first three months or six months of their working, until they had gained experience, but as a permanent arrangement discontinuous supply would be intolerable. Electricity is not a luxury or a toy; the supply will henceforth be a necessity of life.

(*b*.) *Constancy of Supply.*—The constancy of supply to a given consumer depends on the maintenance of what in the Provisional Order is termed the *pressure* in the mains. In order that the consumer may have a constant supply the pressure in the mains near his house must be kept constant. This is not sufficiently provided for in the draft order.

A standard pressure (21 *b*.) and (21 *e*) is to be fixed by the undertakers and sanctioned by the Board of Trade; then it is provided that the difference of potential (21 *c*.) shall not at any point vary more than 10 per cent. from the corresponding standard pressure. It is, however, expressly stipulated that the "standard pressure may be different for different points of the main, and for different hours during the period of supply."

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As worded I consider that this allows the undertakers at certain points of the town to have normally a pressure 10 per cent. in excess of the prescribed standard, and at other points a pressure normally 10 per cent. below the prescribed standard. I think this an excessive allowance, and I would reduce the whole variation to 10 per cent., *i.e.*, to 5 per cent. on each side of the standard pressure.

But two distinct questions appear here to be mixed—the variation between different points of the mains and the variation at any one given point. These two questions are closely connected, but are not identical. A variation of pressure at any one spot of 10 per cent. from the standard pressure would be intolerable. It would cause continual failure of the incandescent lamps by allowing them to fall to a dull red; or, on the other hand, by raising them to excessive incandescence, it might break and extinguish them suddenly. Even 5 per cent. on each side of the standard would prove inconvenient, and the commercial exigencies of satisfying their customers will lead the companies to give much greater steadiness than this, but I would not render a a variation within this moderate range penal.

There will be no great hardship in allowing a difference of pressure in different parts of the town of 10 per cent., provided at each point the fluctuations throughout the day did not exceed 5 per cent. The two ideas may, perhaps, be kept distinct by calling the one place-variations and the other time-variations. The place-variations might be 10 per cent., but the time-variations should not exceed 5 per cent. I must, however, observe that I see great difficulty (with any method of supply at present known) in so arranging the times that a place-variation of 10 per cent. might occur without *ipso facto* rendering an occasional time-variation of the same amount possible; it may, therefore, be most prudent to demand the 5 per cent. variation in both respects. It should also be noted that all the regulations concerning standard pressure are applicable only to the *parallel arc system* (11 *a. b. & c.*).

Provision must be made that even within the 5 per cent. limit the pressure be not allowed to vary rapidly or oscillate up and down, otherwise a very painful effect will be produced on the eyes. The frequent waxing and waning of the light, consequent on a change of pressure, may be produced by the unsteady running of the engine or dynamo.

The regulation of constant standard pressure approximately equal throughout the main is quite inapplicable to the "Series System" (11 *d.*). For this system a completely distinct set of regulations are required; the pressure is necessarily different at every spot. This system can only be used for arc lights, and is unsuited for domestic purposes. The regulation necessary to ensure constancy in a series system might run as follows:—When the series system is adopted, the undertakers shall state to the consumer the current in amperes which they consider necessary for the purpose indicated by the consumer. They shall also inform the local authority of the number of amperes which they intend to supply through the given circuit; after this they shall be bound, unless relieved by special agreement, to supply a current through this circuit at all hours of the day and night which does not vary by 5 per cent. from the "stated current."

Should they or the consumer desire a change in the stated current, this should only be made after giving notice to the local authority, and if it should appear that the consumer had been misled by the undertakers and so had erected unsuitable apparatus inside his premises, the expense, or some part of the expense, of any alteration should fall on the undertakers. The essential difference between the two systems is that in the one case the pressure must be constant, in the other case the current.

When alternating currents are adopted, the number of alternations per minute should be maintained constant. This number might be fixed differently on different mains, but once fixed, the undertakers should not alter it by more than 5 per cent. from the stated number. If, however, the consumers could show that they suffered by any defect or excess in the number of alternations, then the local authority should have the right to call upon the undertakers to make the necessary change in their apparatus.

(*c.*) *Necessity for Revision.*—It is not possible at this moment to foresee what pressure in the mains will be most advantageous for all purposes, present and future. It is most probable that hereafter separate mains at different pressures will be required. It is almost certain that changes will be required in the pressure first adopted. Nevertheless, these changes when made will involve alterations which may be great and expensive in the internal fittings for private and public purposes. The undertakers require the leave of the Board of Trade before changing the pressure. I see no provision made by which the local authority may call on the undertakers to make the change, but I think they should have this power, also the power of calling on the undertakers to lay down new mains at a different pressure on showing that a reasonable probability of profit exists, and perhaps subject to the approval of the Board of Trade. I also think that a provision should be inserted providing for the compensation of the consumer in case the pressure is changed by the desire of the undertakers in such a way as to throw fresh outlay on the consumer.

The powers taken under (11) seem to me reasonable, but the company may begin by selecting one of these systems, which, as knowledge advances, may be found less advantageous than some other system, either described in (11) or as yet unknown. Provision seems to me to be necessary for facilitating a change either on the demand of the undertakers or of the local authority without damaging the consumer (*vide* 31). Provisions similar to those suggested above seem to me to meet the case, but it might be reasonable to give the local authority the power to demand a change, in case some other system was in other towns proved to be more efficient, even though the change might not be immediately profitable to the undertakers. In a seven years' license I would not insist on these points, but it is impossible to foresee the developments of electrical science and apparatus during the next twenty-one years.

It will be seen hereafter that I do not contemplate in all cases forbidding the use of what are called "earth returns" (11), but I think that the local authority should have the power of forbidding earth returns if from any cause these should prove inconvenient. I apprehend that the Board of Trade already has the power of forbidding these if they should hereafter be proved to be dangerous in any unforeseen way; but, without being dangerous, they may prove highly inconvenient, possibly causing the decay of water or gas pipes, or interfering with the telephone system, or with some new electrical system as yet unthought of. The powers given to the local authority to call upon the company to make extensions or changes should be subject to some appeal. The Board of Trade seems to be contemplated as the natural court of appeal, but I may venture to suggest that they will only be able to decide these scientific questions on the advice of skilled experts, and I would ask you to consider whether in some cases procedure might not be simplified if the President of the Institution of Telegraph Engineers, or some person appointed by him, were at once named as the arbitrator, to decide whether certain demands were reasonable. It is for the legal advisers of the local authorities to devise how a clause should be framed giving the towns a power of revising the terms granted to the undertakers, but I conceive it to be my duty to point out the many ways in which revision may become desirable.

(*d.*) *Supervision.*—Clauses 46 to 51 contain provisions allowing the Board of Trade to test the mains for insulation and conductivity. I fail to see what good result is to come of these tests. Want of conductivity and bad insulation will cause loss to the undertakers, but this very fact will ensure the employment of proper conductors and insulators. With such precautions as I elsewhere advise, no danger can arise from defective conductivity or insulation, and I should, in the interests of the local authorities, prefer that these clauses should be deleted. I fear that the approval of the Board of Trade may occasionally be used as a protection to the undertakers, to which I think they are not entitled. The lines may be well insulated and of good conductivity, and yet be wholly unsuited for the work they have to do. They may be of insufficient dimensions; they may be insufficiently protected against injury; they may be insulated with a material of good electrical properties, but bad mechanical properties, as by being too soft; they may be badly arranged in many ways, and yet when a faulty service results from these defects, the undertakers may plead that the lines were passed by the Board of Trade. If the pressure specified is maintained at the customers' poles, the local authorities have, so far as I can see, no interest in requiring either good conductivity or high insulation.

I would not delete 52, which may possibly be useful, though I should not recommend that it be largely applied. Similarly, 53 gives a useful power, 55 requires extension. The undertakers should, at the points referred to in this clause, set up three instruments—known respectively as ergmeters, ammeters, and voltmeters—measuring respectively the energy, the current, and the difference of potential. The ammeter is absolutely essential to allow the authorities to verify that the condition inserted in Sec. 62 (a) is complied with. The records should, when possible, be *continuous*, and the burden of showing that a continuous record is impossible at reasonable cost should fall on the undertakers. Copies of the record should be furnished daily to the local authorities. If it be said that these instruments are not yet perfected, it may be answered, with the utmost confidence, that if not yet perfect in all respects they will very shortly be so made as to be far more trustworthy than gas meters. The continuous record of what is happening at the source of the supply will be most valuable to the local authority as enabling them to ascertain whether any complaints as to the supply depend on causes over which the undertakers have control. They can be

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sent to men of standing for their opinion in case of doubt, and do not require the appointment by the towns of electricians of equal skill with those of the undertakers—a burden from which the towns should be saved.

I would insert a fresh clause to the following effect:—The undertakers shall, at their own expense, fix at suitable points in connection with the mains, instruments capable of showing the pressure in those mains at all hours of the day and night, and such as can be read by persons of moderate skill. These instruments are called voltmeters. The places where these are fixed should be determined in concert with the local authority, and the inspector of the local authority should have access to them. The undertakers should be bound to use self-recording instruments so soon as these can be produced at a reasonable price. That this can be done is undoubted. The one point on which the local authorities may insist is that the standard pressure fixed for each main shall be maintained day and night without the 5 per cent. variation, and they may call on the undertakers to prove that this has been done. The borough engineers will be perfectly competent to examine these records.

I would further insert a clause giving each customer the right to have, on payment of a reasonable charge, one of these pieces of apparatus fixed either permanently or temporarily in connection with the poles inside his house, with the object of ascertaining whether the standard pressure is maintained for his particular supply. In connection with this point I must hereafter revert to Sec. 21 (d), which I consider objectionable.

The meters of all kinds should be subject to verification of the same kind as is now applied to gas meters.

While, however, I would relieve the local authority from all scientific supervision of the undertakers' plant, I think a clause would be most useful requiring the undertakers before executing any works to send full particulars of those works to the local authority; thus they should be required to furnish accurate maps showing the proposed and accurate position of all mains, distributing boxes, and testing boxes. They should send in drawings of all the apparatus they propose to employ except the engines, dynamos, and special appliances required on any premises where the electricity is generated. Thus the local authority should be informed of the size of every main; the mode of insulation employed; the manner of protecting the mains as by cast-iron pipes or otherwise; the form of the distributing boxes and testing boxes; the design of any pole or support visible in the public part of the town. I would not give the local authorities any veto on scientific grounds. This would shift the responsibility to the wrong persons; but, on grounds of what we in Scotland term "amenity," I would give the local authority power to object to the design of any structure visible in the public streets. And further, I would give a veto on the ground that the proposed works would interfere with some other necessary or desirable public or private works. Thus the proposed erections might interfere with tramways, gas distribution, water distribution, *fire escapes*, telephone wires and ordinary traffic. Moreover, the towns would be entitled to object if the mode employed of laying and repairing the mains was not that which would cause the least interruption to ordinary traffic. Already plans exist by which the mains can be repaired and multiplied without breaking up the street, and improved methods of doing this will undoubtedly be devised. I am not, therefore, in favour of at present defining exactly what the undertakers may or must do, but should prefer to call upon them to deposit tracings of all their working drawings, and giving the local authority power to object on the grounds above stated, subject to appeal.

In respect of apparatus employed on the undertakers' premises I would only call upon the undertakers to state the indicated horse-power which the engines were capable of exerting, to give a general description of the dynamos they employ, and to keep the local authorities informed of any material changes they make from time to time in their system. The mere necessity of making these statements will act as a useful check against abuses, even when the local authority retains no power of veto.

(*e.*) *Consumers' Right to Supply.*—The provisional order does not, in my opinion, ensure that all consumers who may reasonably demand electricity shall be supplied. In Schedule C, Section I, it is stipulated that the undertakers may charge £3 10s. per quarter for any quantity up to 100 units; this amounts to a refusal to supply small customers. In my opinion every consumer should have a right to be supplied, even if he only wants one incandescent lamp occasionally. All that the undertakers have a right to require is that the consumers should themselves pay the charges of connecting their lamps with the mains, and of the necessary meters. There is no hardship whatever in requiring them to supply small customers or persons who only occasionally use electricity. No scientific difficulty exists to justify this limitation. I will return to the point under the head of price. In Section 26, I think the distance, 50ft., too small. I see no hardship in extending this limit to 100ft., or even more, if the cost of the service line is, beyond 20ft., to fall on the consumer.

If, hereafter, mains of different pressures are employed in the neighbourhood of his premises, the consumer should have the right to choose from which main he will be supplied. If in some mains an alternating current is used, in others a constant current, the consumer should have the right of choice; further, if he desires to be supplied from all the mains in his neighbourhood separately, he should have the right to these several supplies which he may desire for several reasons—as to avoid all risk of interruption, or to use the electricity for different purposes.

(*f.*) *Size of Mains.*—The size of the mains should be such that for the contemplated supply the current through the main should not exceed a certain number of amperes. This in my opinion might be fixed at about 500 amperes per square inch, but I should not object to 800, although this would, I think, be less advantageous to the undertakers. It is, I think, important to require that the undertakers (in giving such notice of their intentions as I have recommended under head *d*) state what maximum supply they contemplate giving, and at the same time to specify the size of the main, and, subject to such possible revision as is alluded to under head *c*, I would fix at once the quantity of copper to be employed. This will prevent the undertakers from laying down inefficient mains in the first instance, and is a wholly distinct question from that of safety. It will be found that, for reasons of safety, the undertakers are prepared to submit to a limitation of current through any main, and there is, therefore, no hardship in requiring them at once to fix the quantity of metal they will use to convey a given current. The limit for safety is hereinafter fixed at 1,200 amperes. A further security that mains of sufficient size are put down would be given by a clause requiring that no change inside premises supplied should cause a sensible variation of pressure at the poles; this is not sufficiently provided for by the 5 per cent. limit named under head *b*. It would be intolerable if turning on or off lamps on the premises caused a charge of 10 per cent. (*i.e.* from lowest to highest limit) in the available pressure.

(*g.*) *Retail Dealers.*—Difficulty may hereafter arise from what I may term retail dealers in electricity. The undertakers cannot object if certain shops bottle up a certain quantity of electricity, as in storage batteries, and in carts send it elsewhere to be employed in any way—but the following case is worthy of consideration, and I am not sure that it is provided for in the order. A retail dealer may find it worth his while to extend his service lines to several neighbouring houses which are not entitled to a supply direct from the mains—he complies with all the conditions laid down, gives notice of the quantity he requires, and pays for it. Is he to be at liberty to supply his neighbours in this way, and, if so, to what extent? He might supply whole streets and be subject to no regulations.

(*h*). *Notice to be Given by Customers; Advice to be Given by Undertakers.*—I think it very objectionable that (28) the intending customer should be required to state the *maximum current* with which he desires to be supplied. He will usually not have the knowledge enabling him to make this statement. He may fairly be called upon to state all the uses he proposes to make of electricity simultaneously; then the responsibility of advising him what current he requires should fall on the undertakers, who should also give him all necessary particulars as to the service wires he requires to bring the electricity to his poles. Then the customer may fairly be required not to exceed the maximum of which he has given notice; but, *per contra*, if the advice given him proves wrong, the expense of any alteration in the service wires should fall on the undertakers in part or wholly. Proper clauses framed with this object would obviate the necessity for Clause 21 (*d.*), which in any case seems to me objectionable. The undertakers should be the scientific advisers of the customers up to the poles, and I should be prepared to trust to the ordinary commercial motives as a safeguard against any excessive demands by the undertakers for wires of great size. They must be responsible for everything up to the poles, and it is therefore reasonable to leave the design as well as the execution in their hands. If the customer *prefers* to state the maximum quantity he requires rather than state the uses, he should be at liberty to do so. In all cases where the undertakers supply the apparatus they should be bound to state the conditions for their effective working in respect of current and pressure, and their responsibility would then extend to the interior of the house.

I may here draw your attention to the fact that the 50 amperes per house mentioned in (29) will be frequently exceeded. I do not, however, see that Clause 29 is objectionable. 50 amperes will suffice for about 35 Swan lamps, and this number will often be exceeded.

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(*i*). *Penal Clauses.*—I express no opinion as to the sufficiency of the penalties in 57, 58, and 59, but Clause 60 is surely objectionable. Even in the present state of electrical science, a failure to comply with the terms of the order recurring frequently in one day would show great ignorance or carelessness. There will be no more difficulty in supplying electricity than in supplying gas or water. I think the clause should be struck out.

Further penalties are required, or further definition of what a failure to supply means. I would suggest that the accidental extinction of more than one light simultaneously in a house should, of itself, be held to show that the undertakers were in default and should entail a small penalty.

Secondly, that the simultaneous accidental extinction of all the lights, or a considerable portion of the lights on a given main, should subject the undertakers to a penalty increasing with the duration of the time which the extinction lasts.

I would also provide a penalty for the proved unsteadiness of the lights, even though the waxing and waning remained within such limits as are consistent with the permitted five per cent. variation of pressure If the undertakers carry their 10 per cent. limit the waxing and waning might be quite intolerable within this margin. In what is written above "extinction of lights" should be held to include the cessation of any action to which the electricity is applied.

A remedy should, I think, be provided for the following injury to which the customers will be liable. It is possible that, by some accidental variation of pressure in the mains, the lamps throughout a whole establishment, or indeed throughout whole streets, may be simultaneously broken. I mean that the carbon filaments of the incandescent lamps may all be burnt up in one minute by a change from which the safety fuse does not protect the customer. Other injuries may be done to other apparatus. A simple remedy for this wrong should be provided.

II.—Price.

(*j.*) *Cost of Incandescent Lighting.*—The price which the undertakers propose to fix as the maximum which they are entitled to charge will make incandescent domestic lighting about twice as costly as lighting by gas at 4s. per 1,000 cubic feet. The calculation is made as follows:—A burner using five cubic feet per hour and giving what is called twenty candle light would consume gas worth at the above rate $\frac{24}{100}$ths of a penny per hour. One incandescent Swan lamp to give the same lights uses 1·4 ampere with a pressure of 50 volts. The unit by which the charge is to be fixed (Schedule C) is 1,000 volt-amperes; the above quantity in volt-amperes is the product of 50 × 1·4 divided by 1,000, or $\frac{7}{100}$ths of a unit. Since each unit is to cost 7d., this makes the cost of the Swan lamp $\frac{49}{100}$ths of a penny per hour, or about double that of gas.

I am not prepared to say that in the present condition of electric lighting this rate of charge as a maximum is unreasonable. It is not impossible that consumers may find that they can supply themselves with electricity by means of a gas engine at a cheaper rate, but if so the undertakers will certainly lower their prices.

(*k.*) *Cost of Arc Lighting.*—The cost of arc lighting would per candle-power be much smaller than that reckoned above for incandescent lighting, but comparisons with gas are for this system in my opinion misleading. The result produced is so extremely different that the two systems can hardly be compared. Since, however, for incandescent lighting, the price proposed is not unreasonable, I am prepared to admit that it is reasonable for arc lighting.

(*l.*) *Cost of Motive Power.*—The price named will be prohibitory as regards motive power. The number of volt-amperes divided by 746 gives the horse-power represented by that supply; or, in other words, 746 volt-amperes would be required per hour to give one horse-power if perfect efficiency were secured. This perfect efficiency is even theoretically unattainable; but it is probable that a high degree of efficiency will soon be attained. Even, however, allowing 90 per cent. of efficiency, 830 volt-amperes would be required per hour per horse-power, or $\frac{83}{100}$ths of the unit in the provisional order. The cost of this would be 5·8d. per hour. A gas engine will supply the power for less than one penny per hour. In all these calculations I have taken the cost of electricity at 7d. per unit, because, as I shall presently show, I think the other figure given, of £3 10s. per quarter, inadmissible. It might, perhaps, be easy to induce the undertakers to insert a clause specially contemplating the revision of price in respect of motive power by presenting to them the following consideration. If they are allowed, as I propose, to employ distributing mains at high pressure, they will be able to give electricity much more economically by these mains than they can by the low-pressure mains employed for electric domestic lighting. I would therefore suggest that a clause be inserted providing that if the employment of high pressure be now or hereafter authorised, the price charged for electricity from a high-pressure main shall be substantially lowered, and fixed by arbitration, so as to give a reasonable profit.

(*m.*) *Mode of Charging.*—The mode of charging proposed (Schedule C), viz., a fixed sum per unit of 1,000 volt-amperes is in itself reasonable. It is equivalent to charging a sum proportional to the horse-power required to produce the supply given. When the pressure is approximately constant, this is a fair basis. As already stated, when the pressure varies, the mains to give a certain power vary in dimension, becoming smaller as the pressure increases; therefore, it is reasonable that the price should diminish when the pressure increases, but with a fixed low-standard pressure for the ordinary distributing mains, I have no objection to make either to Section 1 or Section 2 of Schedule C. Both sections provide for charging in substantially the same way, and the liberty which the undertakers reserve to themselves of measuring the number of units supplied in one of two ways is a freedom which they may properly be allowed, seeing that we do not yet know whether meters for measuring current or for measuring energy can be most cheaply made, most easily kept in order, or regulated most accurately. I have myself no doubt that cheap and accurate meters of all kinds can be produced. The mode of charge suggested in Section 3 (Schedule C) would also be unobjectionable if the consumer were the person entitled to elect that he should be charged in this way. As it stands, however, the proposal is wholly inadmissible, and is, perhaps, the strangest clause in the whole order. The consumer is supposed to state the maximum quantity he will require per hour under Section 28. I have already said that this burden should not fall on the consumer, but whether named by him or by the undertakers there is no doubt that before the service wires are fixed a maximum quantity for a given supply must in some way be settled. Let us then suppose that this maximum quantity is settled; it may be a maximum which the consumer may only require once a year, as when he gives a ball, or more probably once a month or so. This maximum may on these occasions be tenfold what he will use on an average, and yet the company, under Section 3, would have the right to elect to charge him as if he were using the maximum quantity for every hour during which any electricity was being supplied. The absurdity does not even stop here. Let us suppose that the consumer abandons the idea of asking for a maximum supply beyond his average wants (although this would be a hardship); nevertheless, he must fix his maximum as sufficient for the largest number of lamps which he will use at once on any one evening. The proposal, as I read it, is to charge him for every minute during which even one lamp is lighted at the rate calculated from that which the undertakers are entitled to charge when the full supply is on. In other words, if the consumer asks for 50 lamps, and is charged 7d. per unit for electricity when 50 lamps are burning, he will be charged 29s. 2d. per unit when he is only burning one lamp. The proposal is so monstrous that I have endeavoured to find some other meaning than that which I attach to this clause, but I fail to find an alternative construction. I imagine this proposal must have originated in some doubt whether good meters could be produced, whereas there would be no doubt that the simple flow of the electricity into the house would drive a clock registering the number of hours during which electricity was turned on. For certain purposes such a mode of charging would be quite fair, but to give the undertakers the power to adopt it whenever they please, and to base their charge on the maximum supply at full prices, is quite impossible. Section 4 is open to similar objections.

(*n.*) *Suggestions as to Price.*—Some revision of the price charged should be arranged. It is impossible to foresee what will be a fair charge twenty-one years hence. A limitation of dividends might be considered, but seems to me false in principle, since it tends to discourage further improvements when the maximum has once been reached. A most favoured nation clause occurs to me as possible of the following kind—that the undertakers shall be bound to afford all facilities and modes of supply which shall from time to time be proved to be remunerative in any town of Great Britain unless cause can be shown why these modes of supply are inapplicable to Great Yarmouth or the special town in question. Moreover, that the rates charged for all modes of supply shall not exceed those charged for similar supplies of electricity in any other town of Great Britain by more than 20 per cent., unless special cause can be shown for the excess in the town in question, to the satisfaction of arbitrators. The 20 per cent. of excess would prevent the question of rates being mooted in a vexatious and unnecessary manner; and some such clause seems necessary to prevent companies which are burdened with heavy patent royalties from acquiring a disadvantageous monopoly. Many companies are weighted by agreements taxing them heavily for the benefit of certain patentees. So long as the instruments protected by the patents really give a better supply than others which

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are supplied at a cheaper rate, this burden is perfectly legitimate and advantageous to the consumer; but it is at least conceivable that hereafter apparatus less heavily burdened by royalties may give a still better supply, and it would then be greatly to the disadvantage of the towns that they should be in the hands of persons bound to use the more expensive apparatus. Under these conceivable circumstances, the royalties should be paid by a diminution in the dividends, and not by the consumers, who have no interest in the employment of one machine rather than another. At the same time, it is obvious that few companies for the supply of electric lighting have been formed, or would be formed, except on the basis of some special patent, and there would be no objection to this if such a most favoured nation clause as I have suggested were incorporated in all provisional orders. If some device of this kind be not invented it will become the interest of all towns to hold back and delay the introduction of electric lighting; for those which come last will be best served—obtaining the benefit of the experience derived on the towns first supplied.

(*o.*) *Price of Fittings.*—I think it would be desirable that the undertakers should be bound to supply fittings of all descriptions such as they approve of at prices to be fixed from time to time by arbitration, so as to allow of a good trade profit. If this be not done, the undertakers, in answer to complaints, will often be able to lay the blame on the internal fittings. While consumers should be at liberty to buy these fittings anywhere and of any make, the company should be bound to supply those which it thinks best. Patterns of these fittings, with the prices fixed, should be deposited with the local authorities.

When lamps or other forms of apparatus are supplied to customers by the undertakers, means should be provided by which the customer can have, at a cheap rate, tests made of their efficiency.

Should the undertakers strongly object to supplying very small customers—although this seems to me impolitic on their part—a sliding scale of prices might be agreed on by which a somewhat larger rate might be charged when the average consumpton fell below a certain amount. As another protection to the undertakers, it might be reasonable to allow them a greater latitude as regards the perfection of their service, their mode of charging, and their prices during the first three years after beginning their supply.

ON INCANDESCENT LIGHTING.*

BY WILLIAM SIEMENS.

(CONTINUED FROM PAGE 96.)

Of two equally large installations of incandescent lights—the one carried out with the Swan and the other with the Edison lamp—the former would accordingly (as the Swan requires about double the current of Edison) necessitate about four times as expensive a "lead." This circumstance, so unfavourable for the Swan lamp, is of more consequence the larger the installation and the farther the current is produced from where it is used, so that central installations with Swan lamps can only be carried out with more or less difficulty.

One can, it is true, obviate the disadvantage arising from the costliness of the conductor with lamps of low E.M.F., by taking refuge in certain combinations of the parallel and "series" systems of circuiting the lamps. The number of these combinations is unlimited. In the Swan lamps we frequently find that two or more lamps are put "in series," and these pairs amongst themselves are circuited "in parallel;" or that the installation consists of two or three great groups circuited "in series," each of which consists of an equal number of lamps circuited "in parallel." The first arrangement possesses the disadvantage that simultaneously with the one lamp the entire pair become extinguished. Under the second arrangement the going out of one lamp is not at once accompanied by that of another. It must be noticed, however, that if any branch circuit is broken the current through the other branch is increased, exposing the lamps therein to danger.

For certain installations the group arrangement will be acceptable (as, for instance, at the Savoy Theatre). In cases, however, where the lamps are required to burn singly, independently of each other, and where it is desirable to be able to put in and out of current single lamps, or a larger number of the lamps in the same circuit, the single multiple arc system is preferable.

I will now speak of lamps of different intensity, but which burn in the same circuit in greater detail.

I assume similarity of materials, molecular structure, and temperature. Each square centimetre of surface will have a fixed radiating capacity, whether the surface belongs to a thin or thick carbon, or whether a lamp of high or low tension is concerned. A unit surface would correspond to a certain wax candle, and hence the illuminating power of the lamp may be given in candles.

How shall the lamp be constructed so that lamps of different size may be put into the same circuit? The answer depends upon several conditions. Are the lamps to be in multiple arc or in series, are they adjusted for a constant difference of potential or for a constant strength of current—*i.e.*, is E or C to be maintained constant? As we have assumed similar materials and temperature, if l represents the length, d the diameter of the carbon taken as round, and R_s the specific resistance of the same : $E \,.\, C = l \,.\, d$.

Let us first consider the case where the lamps are circuited in series, and the current constant:

$$C^2 R d = l\,d; \quad \frac{C^2 R_s\, l}{d^2} = l\,d; \quad C^2 R_s = \text{const.} = d^3; \text{ or } d = \text{const.}$$

The condition, therefore, for lamps of different illuminating power burning in series in the same circuit is, assuming similarity of temperature, that the diameter of the carbon be in all lamps the same. Lamps of different luminosity can thus be distinguished by their length. Practically, of course, this circumstance is of no importance, as for a large number of lamps in series the E.M.F. required would become too considerable, and for each lamp, taking it as of 10 ordinary candle-power, certainly not less than from 30 to 40 volts would be required, assuming the conductor not to be thicker than that of the Swan lamp, and to be kept within the limits of temperature.

The usual mode is for lamps to be connected parallel. On this account the different lamps must require the same E.M.F.

That is, $E\,C = l \,.\, d$ or $\dfrac{\frac{E^2}{W_s}\,.\,l}{d^2} = l.d$ or $\dfrac{E^2}{W_s} = \text{const.} = \dfrac{l^2}{d}$. Let l_1 and d^1 be the dimensions of a given lamp, and l^1 and d^1 those of one required to use similar E.M.F. and temperature, then $\dfrac{l^1}{d^1} = \dfrac{l_1{}^2}{d_1} = \text{const.} : l^1 \,.\, d^1 = m \,.\, l_1 \,.\, d_1$, in which m shows the proportion between the two surfaces or candle-powers. The two unknown (quantities) l^1 and d^1 can be fixed therefrom.

The existence of lamps of different luminosities in the same circuit with constant difference of potential is dependent upon $\dfrac{l_2}{d} = \text{const.}$ Lamps are not only distinguished by their length of carbon, but in a higher degree by its diameter.

The E.M.F. chosen for lighting purposes will be as high as possible. Assuming identical materials and identical temperature, a certain surface corresponds to 10 candle-power (a less luminary would hardly be required for domestic purposes). If the carbon is of the smallest diameter possible (*i.e.*, so that it meets the requirement of sufficient stability), the length is made such as to give the radiating surface required for 10 candles. A unit size is thus determined by the illuminating power which one desires to give to the smallest lamp of the system, and upon fineness of the carbon without endangering durability.

Considered from a purely theoretical point of view, one might choose an E.M.F. of an unlimited value, and thus realise the dictum that the power of a light-installation is independent of the distance of the source of the current (as Deprez has in a similar manner formulated for the effective power of the transmission of energy).

The condition, therefore, that the effective power of a transmission of power remains constant under variation of its distance is $\dfrac{E^2}{W} = \text{const.}$ The same holds good of the effective power of a light installation. In it $\dfrac{E^2}{W}$ represents the power consumed in the lamp, which corresponds to a certain illuminating power. In the same measure as the distance or the resistance of the conductor is increased must also the resistance of the carbon be increased, so that the proportion between the work lost in the conductor and the total work remains the same. As the illuminating power of the lamps has not to be altered, the required difference of potential is shown by the relation $\dfrac{E^2}{W} =$ constant. In like manner is the new strength of current determined by $C^2 W = \text{constant}$. The larger W and E are made, so much the thinner is the carbon filament, and as the uttermost limit in this respect is soon reached, in the impossibility of making the carbon filament indefinitely thin lies the practical limitation of the universal dictum—that the effective power is independent of the distance.

Whilst in the case of incandescent lamps the limitations of this dictum lie in the small variations W is susceptible of, in the

* Translated from the *Electrotechnische Zeitschrift*, March, 1883.

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transmission of power the obstacle is in E, or in the difficulty of insulating the wires.

With the present materials for carbons, and in the actual position of the manufacture, I do not believe that more than from 100 to 110 volts can be employed even for 10 candle-power lamps. The E.M.F. at which the incandescent lights of the firm of Siemens and Halske are adjusted is 105 volts. The close agreement of our lamps with the Edison lamps in respect to E.M.F. is more than accidental. It is, as I have explained, founded on the nature of things. It must here be freely acknowledged that in the beginning of the era of the incandescent light, when Edison constructed his first lamp, he recognised the suitability to the purpose of the highest possible E.M.F.

The firm of Siemens and Halske produce lamps of three different illuminating powers, of 10, 16, and 25 candles.

The E.M.F. required is 105 volts.

Candle-power. *	Diameter.	Length.	Section (at area).	Surface.
10	0·15	110	0·017	50
16	0·20	125	0·031	75
25	0·27	145	0·056	120

It is an actual æsthetical necessity that these lamps, particularly when present in the same room, should burn with uniform tone and tint, and this, provided the carbon material is the same, is secured by uniform temperature. In this case the superfines of the different carbons must be (stand) as the corresponding illuminating powers, which is approximately the case in the above-mentioned lamps.

(TO BE CONTINUED.)

A HISTORY OF ELECTRIC TELEGRAPHY TO THE YEAR 1837.

BY J. J. FAHIE, MEMB. SOC. TEL. ENGS. AND ELECS.†

(CONTINUED FROM PAGE 92.)

Between 1705 and 1711, Hauksbee made many valuable and interesting observations, of which we must content ourselves with a brief *résumé*, referring our readers for fuller accounts to the original papers in the *Philosophical Transactions*, or to Priestley's excellent "History and Present State of Electricity," pp. 15-23, 5th Ed. In 1705, he showed that light could be produced by passing common air through mercury, contained in a well-exhausted glass receiver. The air, rushing through the mercury, blew it against the sides of the glass, and made it appear like a body of fire, consisting of an abundance of glowing globules. In repeating this experiment with about three pounds of mercury, and making it break into a shower, by dashing it against the crown of another glass vessel, flashes resembling lightning, of a very pale colour, and distinguishable from the rest of the produced light, were thrown off from the crown of the glass in all directions.‡ Hauksbee likewise showed that considerable light may be produced by agitating mercury in a partially exhausted tube; and that even in the open air abundance of flashes of light are discoverable by shaking quicksilver in any glass vessel.

In a subsequent series of experiments on the light produced by the attrition of bodies *in vacuo*, he showed that glass, when thus excited, emitted light in as strange a form as lightning, particularly, when he used a rubber that had been previously drenched in spirit of wine. In all these experiments Hauksbee had no notion of the electrical origin of the light, and in saying that it resembled lightning he was only using a simile, without any suspicion of a closer connection.

Like Sir Isaac Newton, Hauksbee employed a glass globe machine, as he thought that this material was capable of more powerful effects. When exhausted of air, and turned briskly, the application of his hand would produce a strong light on the inside; and, by re-admitting the air, light appeared on the outside also. By bringing an exhausted globe near to an excited one, he found that a light was produced in the former, which soon disappeared; but which immediately reappeared, with great beauty, on again exciting the globe.

The following experiment must at that time, and indeed long after, have been considered one of great singularity. Having coated one half of the inside of a glass globe with sealing-wax, which in some places was an eighth of an inch thick, and, therefore, quite opaque, he exhausted it and put it in motion. On applying his hand, for the purpose of excitation, its outline soon became distinctly visible on the concave surface of the wax, which thus appeared to be transparent, although before excitation it would only just allow the flame of a lighted candle to be seen through it in the dark. The same result was obtained when pitch, or common brimstone, was substituted for the sealing-wax.

Besides light and crackling noises, Hauksbee also noticed that an electrified body was able to produce a sense of pain (the electric shock) in the hand, or face, that touched it—an observation which is also claimed for his friend, Dr. Wall.

This latter philosopher is, however, best known as being the first to suspect the identity of lightning and electricity. The happy thought was suggested to him, as he tells us in a paper read before the Royal Society in 1708, by the sparks and crackling sounds produced by the friction of a large stick of amber against a woollen cloth. "Upon drawing," he says, "the piece of amber swiftly through the woollen cloth, and squeezing it pretty hard with my hand, a prodigous number of little cracklings were heard, every one of which produced a little flash of light; but when the amber was drawn gently and slightly through the cloth, it produced a light, but no crackling. By holding a finger at a little distance from the amber, a crackling is produced, with a great flash of light succeeding it; and what is very surprising, on its eruption, it strikes the finger very sensibly, wheresoever applied, with a push or puff like wind. The crackling is full as loud as that of charcoal on fire; nay, five or six cracklings, or more, according to the quickness of placing the finger, have been produced from one single friction, light always succeeding each of them. Now I doubt not but on using a longer and larger piece of amber, both the cracklings and light would be much greater. This light and crackling seem in some degree to represent thunder and lightning" (Hutton's *Phil. Trans. Abridged*, Vol. 5, p. 409).

So far, experimenters had worked without any system, and without in the least comprehending the principles on which the effects they produced depended. Highly important, therefore, as were all their observations, the true foundations of electricity as a science cannot be said to have been laid until Stephen Gray, a pensioner of the Charter-house, London, gave to the world that justly celebrated series of experiments which, begun in 1720, only ended with his last breath in 1736.* As from this point the domain widens, we will confine ourselves in the rest of this chapter to noticing only such discoveries of Gray and succeeding philosophers as bear intimately on our subject.

In February, 1729, Gray discovered the principle of electric conduction and insulation, and in doing so might almost be said to have stumbled across electric telegraphy, of which it is the very *alpha* and *omega*. This important discovery was made in the following manner:—Wishing to excite in metals, as had already been done in glass, resin, &c., the power of attraction and repulsion, he tried various methods, such as rubbing, heating, and hammering; but all to no end. At last an idea occurred to him that, as a glass tube, when rubbed in the dark, communicated its light freely to bodies, so it might communicate a power of attraction, which, at this time, was considered the only absolute proof of the presence of electricity. In order to test this he took a glass tube, 3ft. 5in. long and 1 1·5in. diameter, and filled up the ends with pieces of cork to keep out the dust when the tube was not in use. His first experiment was to ascertain if there was any difference in its power of attraction when the tube was stopped at both ends by the corks, and when left entirely open; but he could perceive no sensible difference. Then holding a feather over against the end of the tube, he found it would fly to the cork, being attracted by it as readily as by the tube itself. He concluded from this that the electric virtue, conferred on the tube by friction, passed spontaneously to the cork.

It then occurred to him† to inquire whether this transmission

* These are German candles, and should be converted into English by multiplying by 1·237, and the numbers become respectively 12·37, 19·79, and 30·92.

† The author reserves all rights of translation.

‡ Electric light *in vacuo* was first observed by Picard in 1675. While carrying a barometer from the Observatory to Porte St. Michel in Paris, he observed light in the vacuous portion. Sebastien and Cassini observed it afterwards in other barometers. John Bernouilli, in 1700, devised a "mercurial phosphorus," by shaking mercury in a tube which had been exhausted by an air pump. This was handed to the King of Prussia, —Frederick I.—who awarded it a medal, of forty ducats' value. The great mathematician wrote a poem in honour of the occasion. (Tyndall's "Notes on Electricity.")

* This remarkable man was (so to speak) dying when his last experiments were made, and, unable to write himself, he dictated an account of them to Dr. Mortimer, the secretary of the Royal Society, the day before his death.—*See Philosophical Transactions*, vol. 39, p. 400, 1735-36, or Hutton's *Abridgement*, Vol. 8, p. 110.

† We follow in this and the next three paragraphs Lardner's "Manual of Electricity, Magnetism," &c., Vol. I., pp. 8-9. See also Priestley's "Hist. Elec." pp. 24-39.

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of electricity would be made to other substances besides cork. With this view he obtained a deal rod about 4in. in length, to one end of which he attached an ivory ball, and inserted the other in the cork, by which the glass tube was stopped. On exciting the tube, he found that the ivory ball attracted and repelled the feather even more vigorously than the cork. He then tried longer rods of deal; next rods of brass and iron wire, with like results. He then attached to one end of the tube a piece of common packthread, and suspended from its lower end the ivory ball and various other bodies, all of which he found capable of acquiring the electric state when the tube was excited. Experiments of this kind were made from the balconies of his house and other elevated stations.

With a true philosophic spirit, he now determined to inquire what circumstances attending the *manner* of experimenting produced any real effect upon the results; and, first, whether the *position* or *direction* of the rods, wires, or cords, by which the electricity was transmitted from the excited tube, affected the phenomena. For this purpose he extended a piece of packthread in a horizental direction, supporting it at different points by other pieces of similar cord, which were attached to nails driven into a wooden beam, and which were, therefore, in a vertical position. To one end of the horizontal cord he attached the ivory ball, and to the other he tied the end of the glass tube. On exciting the tube he found that no electricity was transmitted to the ball, a circumstance which he rightly ascribed to its escape by the vertical cords, the nails supporting them, and the wooden beam.

Soon after this (June 30, 1729), Gray was engaged in repeating his experiments at the house of Mr. Wheeler, who was afterwards associated with him in these investigations, when that gentleman suggested that threads of silk should be used to support the horizontal line of cord, instead of pieces of packthread. It does not appear that this suggestion of Wheeler proceeded from any knowledge, or suspicion, of the electric properties of silk; and still less does it appear that Gray was acquainted with them; for, in assenting to the proposition of his friend, he observed, that "silk might do better than packthread on account of its smallness, as less of the virtue would probably pass off by it than by the thickness of the hempen line which had been previously used."

They accordingly (July 2, 1729) extended a packthread through a distance of about eighty feet in an horizontal direction, supporting it by threads of silk. To one end they attached the ivory ball, and to the other the glass tube. When the latter was excited, the ball immediately became electric, as was manifested by its attracting metallic leaf held near it. Next day, they extended their experiments to lines of packthread still longer, when the silk threads used for its support were found to be too weak, and were broken. Being under the erroneous impression that the escape of the electricity was prevented by the fineness of the silk, they now substituted for it thin brass wire, which they expected, being still finer than the silk, would more effectually intercept the electricity; and which, from its nature, would have all the necessary strength. The experiment, however, completely failed. No electricity was conveyed to the ivory ball, the whole having escaped by the brass wire, notwithstanding its fineness. They now saw that the silk threads intercepted the electricity, because they were *silk*, and not because they were fine.

Having thus accidentally discovered the property of insulation, they proceeded to investigate its generalisation, and found that it was enjoyed by resin, hair, glass, and some other substances.

In fact, it soon became apparent that, in this respect, all matter may be said to belong to one of two classes, the one like the packthread and brass wire, favouring the dissipation, or carrying away, of the electric power, and the other like the silk and glass opposing it.*

Armed with this knowledge, Gray and Wheeler, in July, 1729, had the great satisfaction of being able to transmit the electric power through as much as 765ft. of packthread, supported by loops of silk, and in August, 1730, through 886ft. of wire. It is curious to observe that in these experiments, as, indeed, in all others on electrical conduction, we have all the essentials—crude, of course—of a perfect telegraph, the insulated line, the source of electricity in the rubbed glass, the indicating instrument in the down feather, and the earth, or return circuit, the function of which, however, was not then suspected.

* Soon after this, in August, 1729, Gray discovered that when the electrified tube was brought near to any part of a *non-electric*, or conducting body, without touching it, the part most remote from the tube became electrified. He thus fell upon the fact, which afterwards led to the principle of induction. The science, however, was not yet ripe for that great discovery, and Gray, like Otto Guericke before him, and Wilson and Canton after him, continued to apply the principles of induction without the most remote suspicion of the rich mine whose treasures lay beneath his feet, and which it was one of the glories of Franklin to bring to light.

While Gray and Wheeler were pursuing their investigations in England, Dufay, of the Academy of Sciences, and Intendant of the Royal Botanic Gardens, was actively engaged in Paris, in a similar manner. The researches of this philosopher, so celebrated as the originator* of the double-fluid theory of electricity, embraced the period between 1733 and 1737. He added largely to the class of bodies, called *electrics*, by showing that all substances, except metals, and bodies in the soft or liquid state, might be made electric, by first heating them, and then rubbing them on any kind of cloth; and as regards even these exceptions, he showed that they, and, generally, *all* bodies, solid and liquid, could be electrified, if only the precaution were taken of first placing them on glass stands.

In repeating Gray's experiments with the packthread, he perceived that they succeeded better after wetting the line, and, with the aid of this fact, he was able to transmit the electric power along a cord of nearly 1,300ft., which he supported at intervals on glass tubes.

(TO BE CONTINUED.)

COMPANIES' SHARE LIST.

TELEGRAPHS.

Companies.	Closing Prices June 14.		Business Done Week Ending June 14. Highest.	Lowest.
Anglo American	50,	51	—	—
Do. Preferred	82,	83	82¼	82
Do. Deferred	20,	21	20½	20
Brazil Submarine	11¾,	12	11 15-16	11 13-16
Cuba	10,	10½	10⅝	10½
Do. Preference	17,	18	—	—
Direct Spanish	5½,	6	—	—
Do. Preference	15¾,	16½	—	—
Direct United States Cable	12⅝,	12¾	12¾	12⅝
Eastern Telegraph	10⅝,	10⅞	10⅞	10
Do. 6 per Cent. Preference	13,	13½	13⅜	13⅛
Do. 5 per Cent. Debentures, 1899	104,	107	106½	106½
Eastern Extension	11¾,	12	12 15-16	11¾
German Union	10,	10½	—	—
Globe Telegraph and Trust Company.	7,	7½	7 3-16	7 1-16
Do. Preference	12¾,	13	13 1-16	12⅞
Great Northern	12¾,	13	13⅛	12 13-16
Indo-European	31½,	32½	32½	32¼
Mediterranean Extension	1½,	2	—	—
Do. Preference	6,	7	—	—
Reuter's	9½,	10	—	—
Submarine	247,	252	—	—
West India and Panama	1,	1½	1 3-16	1 3-16
Do. 1st Preference	6½,	7	—	—
Western Brazilian	6⅜,	6⅝	6⅝	6⅝
West. Union 7 per Cent. 1st Mortgage	122,	124	—	—
Do. 6 per Cent. Sterling Bonds	103,	106	—	—

TELEPHONES.

Consol. Telephone and Maintenance	⅜,	⅝	½	½
Oriental	⅜,	⅝	—	—
United Telephone	10,	10½	10⅞	9⅝

ELECTRIC LIGHT.

Anglo-American Brush Lgt. (£7 paid).	3¾,	4½	4 1-16	3¾
Do. (fully paid)	6½,	7½	7	6⅝
Hammond Light	2½,	2¾	2 11-16	2½
Pilsen, Joel, and General Electric	⅛,	⅜	—	—
Swan	1⅝,	1⅞	—	—
Maxim-Weston	⅛,	⅜	—	—

TRAFFIC RECEIPTS FOR MAY, 1883.

Companies.	May, 1883.	May, 1882.	Incrse.	Decrs.
Anglo-American Telegraph Company	—	—	—	—
Brazilian Submarine Company	—	—	—	—
Cuba Submarine Company	3,300	3,544	—	244
Direct United States Cable Company	—	—	—	—
Direct Spanish Telegraph Company	1,638	1,038	600	—
Eastern Telegraph Company	—	—	—	—
Eastern Extension Telegraph Company	32,156	33,087	—	931
Great Northern Telegraph Company	22,600	—	—	—
Submarine Telegraph Company	—	—	—	—
West Coast of America Telegraph Company	—	—	—	—
Western and Brazilian Telegraph Company	—	—	—	—

* He can hardly be called its author. For Symmer's claims to this honour, the reader is referred to Priestley's "History of Electricity," page 227. The writer of the article Electricity in the "Encyclopaedia Britannica," 7th edition, says, but we know not on what authority, that this important discovery was simultaneously and independently made by Dufay in France and by White in England.

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NOTES.

TELEPHONY IN DUBLIN.—We understand that the exchange system in Dublin is to be open day and night.

APPOINTMENT.—Mr. P. A. M'Carthy, telegraphist at Dublin, has been appointed to the postmastership of Bandon.

THE FISHERIES EXHIBITION.—It is, we believe, intended to issue invitations to view the electric lighting arrangements at the exhibition.

CHINA.—The Eastern Extension Telegraph Company and the Great Northern Telegraph Company notify the opening for traffic of a new station at Foochow.

TELEPHONIC COMMUNICATION IN BELGIUM.—The Belgian Government, by a decree of June 11th, is authorised to let by tender all the telephonic lines in the kingdom.

UNIVERSITY COLLEGE, LONDON.—The annual *soirée* of the professors was given on Tuesday night, when the visitors were able to visit the lecture rooms, theatres, museums, &c.

PHOTOMETRY.—A new form of photometer was described at the Sheffield meeting of the Gas Institute, by Mr. A. J. Vernon Harcourt, M.A., F.R.S. We hope to be able to find space for this paper in our next issue.

CHANGE OF ADDRESS.—The registered office of the Indian and Oriental Electrical Storage and Works Company will, in future, be 19, Great Winchester-street, London, E.C. Mr. H. C. Heywood is the secretary.

PERSONAL.—M. Marcel Deprez, the author of "The Experiments on the Transmission of Force to a Distance," has offered himself as a candidate for the place in the Academy of Sciences, vacated by the death of M. Bresse, in the Section of Mechanics.

WEST INDIA AND PANAMA TELEGRAPH COMPANY.—The estimated traffic receipts of the West India and Panama Telegraph Company for the half month ended the 15th inst. are £2,540, as compared with £2,544 in the corresponding period of 1882.

THE EDISON CENTRAL STATION, NEW YORK.—The company is at present lighting 429 houses wired for 10,268 lamps from this station. The lighting commenced on September 4, and has been continued without a hitch ever since. New connections are being made daily.

CALEDONIAN CENTRAL STATION HOTEL, GLASGOW.—The laundry, cellars, and engine rooms of this hotel have been fitted up with Swan lamps, and the question of lighting up the whole of the premises by means of the electric light is, we understand, under consideration.

LONDON-PLATINO BRAZILIAN TELEGRAPH COMPANY.—The revenue of the London-Platino Brazilian Telegraph Company for the month of March is estimated at £2,404 (Western Brazilian portion £1,678, land lines £726), as against £2,603 for the corresponding period of 1882.

MUNICIPAL AND SANITARY ENGINEERS.—The annual summer meeting of the Association of Municipal and Sanitary Engineers will be held at Oxford on the 28th and 29th of June. The first paper is one by Mr. Killingworth Hedges, on "The Supply of Electricity by Local Authorities."

THE SUNDERLAND CATASTROPHE.—We hear of at least one child being rescued from the crush in a dying state, and restored to animation by means of electricity. Dr. Abrath, of the Sunderland Hospital for Foreign Seamen, had the gratification of being the successful operator in this case.

EDISON LAMPS.—To the 31st of May, 1883, no less than 334 Edison isolated plants, aggregating 65,145 incandescent lamps, were in operation in various parts of the world. Central stations are not included in this list. The Edison Company states that there has never been a fire or injury in connection with any of its plant.

CHANGE OF NAME.—In pursuance of a special resolution passed at an extraordinary general meeting held on the 28th November, 1882, and subsequently confirmed at an extraordinary general meeting held on the 19th December, 1882, the name of the Anglo-Austrian Brush Electrical Company has been changed to the International Electric Company. Mr. Frank Schloesser is acting as secretary.

TELEPHONES IN MINES.—It is stated that the Belgian company Société Cockerell is employing Bell telephones as a means for communication in their mines. The apparatus at the surface is placed in a convenient position, the connecting wires insulated with gutta percha, and the underground apparatus encased to preserve it from damp. The system has been worked since the beginning of April with great success.

TELEPHONE WORK FOR LADIES. — *Cassell's Magazine* for the current month contains a letter addressed to the publishers from Miss Merlin, lady superintendent of the United Telephone Company, in which she states that one hundred ladies are now employed by that company, nine of the exchange offices being under their care. She speaks in high terms both of the employment itself and of the manner in which the ladies have discharged their duties.

GREENWICH OBSERVATORY.—The report of the Astronomer Royal at the annual visitations states that there has been considerable magnetic activity during the year, the month of November, which was characterised by the appearance of a very large sun spot, being particularly disturbed with remarkable magnetic storms on November 17, 19, and 20, and many interesting cases of lesser disturbance. The magnetic disturbances on October 2 and November 17 were accompanied by brilliant auroras.

THE "ORONTES."—We understand that the Admiralty have arranged with the Swan United Company for the work of lighting by means of incandescent lamps H.M.S. troopship "Orontes," now lying at Chatham. The motor will be one of Gwynne's direct acting engines, driving a Siemens continuous current machine. There will be about 380 lamps used, exclusive of cargo lamps, and will include lamps of 12, 20, and 50 candle-power. These lamps all require the same E.M.F., and are therefore interchangeable.

SLEEPING WITH THE HEAD NORTH.—The following amusing paragraph is going the round of the papers. We should be glad to have some information about these "recent discoveries":—"Recent discoveries in electrical science tell us that the flow of the electric current in the northern hemisphere is more rapidly northward during the night than at other times. If this be so, considering the high electrical condition often experienced by a great many, sleeping with the head due north (or a point west of north), in the flow of this current, would seem likely to be more conducive to perfect rest."

AMERICAN LITERARY IDEAS.—Not long since we felt bound to call attention to the fact that a Belgian paper made free use of our columns without acknowledgment, and

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thought from a remark then made that our American friends would take a hint. A New York paper, the *Electrical Review*, in its issue of June 7, has an article, entitled, "A History of Electric Telegraphy to the Year 1837," by J. J. Fahie. It may happen that our contemporary intends to reprint the whole of Mr. Fahie's articles, and we have only to modestly complain that no mention is made of *The Electrician* in the reprint.

INFORMATION WANTED.—A correspondent sends us a copy of a letter received from a tea plantation in India. The writer of the letter requests his agent to obtain for him an incandescent lamp, &c., as advertised in a paper which has a large colonial circulation. The lamp is worked by a battery, which is to last for 2,000 hours; and the correspondent writes, "as we only use lamps about three or four hours a day, the apparatus would last for 1½ or two years." The reference is to a Mr. D'Or's light and power battery, and to a No. 1 lamp. A little information about this lamp and battery would be useful. Can any reader supply it?

EARTH CURRENTS.—Professor Lenz is about to organise, with the aid of the Russian Geographical Society, a series of observations on terrestrial currents along four lines of Russian telegraphs—Moscow to Hazan and to Kharkoff, and Tiflis to Rostoff and Baku. The necessary instruments are ordered, and the observations will begin as soon as these are ready. These observations were highly recommended, as is known, by the International Polar Committee at its Hamburg meeting, in connection with the magnetic observations of the circumpolar stations, as well as by the Electrical Congress at Paris. Germany has already begun these observations, whilst Austria, Sweden, and Finland are about to start them.

THE THICKNESS OF PLATES IN SECONDARY BATTERIES.—Mr. J. T. Sprague, in an article to a contemporary, says:—"The thickness of the lead must be sufficient to bear its own weight and the strains put upon it after use; the peroxide plate should, therefore, be about double as thick as the other; in large batteries lead 1 millimetre thick is used, which is ·03937in., or about 24 sheets to the inch. One square foot of lead 1in. thick weighs 59·1lb., therefore this would be about 2¼lb. lead. The smaller cells are made of lead little thicker than that prepared for damp walls, which is about 4 to 5 ounces per foot. For ordinary purposes it is probable that sheets of 1½lb. and 1lb. would be most advantageous, with the formation carried so far as to convert ½lb. of the lead to peroxide on the one plate."

ELECTRICAL UNITS.—The following handy table is taken from a lecture by Professor Barker:—

Name.	Unit of	Value in absolute electro-magnetic units.
Coulomb...	Quantity......	10^{-1} or one tenth
Volt	E.M.F.	10^{8} „ one hundred million
Ohm	Resistance ...	10^{9} „ one thousand million
Ampere ...	Current	10^{-1} „ one tenth
Farad	Capacity......	10^{-9} „ one thousand millionth

Watt (ampere volt) rate of work....................	10^{7} (or ten million) ergs.
Horse-power ditto	746 x 10^{7} (or 7460 million) ergs.
Joule.....................heat	0·238 water-gram-degree cent.

ELECTRIC LIGHTING PROVISIONAL ORDERS CONFIRMATION BILLS.—During last week, four additional Bills (Nos. 4 to 7) for confirming Provisional Orders made by the Board of Trade under the Electric Lighting Act, 1882, were introduced, read the first time, and referred to the Examiners. Bill No. 4 related to Barton, Eccles, Winton, and Monton, Carlisle, Croydon, Luton, Margate, Nelson, Rochester, Scarborough, and Sudbury; No. 5, to Bermondsey, Clerkenwell, Hampstead, Holborn, Hornsey, St. George's-in-the-East, St. Giles's, St. James's, St. Martin's, London, St. Luke's, and Wandsworth; No. 6, to Limehouse, Poplar, Richmond (Surrey), Rotherhithe, St. Giles's, St. Olave's, St. Saviour's (Southwark), Shoreditch, and Wednesbury and Darlaston; and No. 7, to Barnes and Mortlake, Hackney, Islington, St. Pancras, and Whitechapel.

LEGAL.—In the Chancery Division of the High Court of Justice, on the 15th June, before Vice-Chancellor Bacon, the case of the United Telephone Company *v.* London Globe Telegraph and Maintenance Company was brought on. Mr. Aston, Q.C., and Mr. Moulton applied to restrain the defendant company from using the Hunnings transmitter, or any carbon telephone transmitters or other instruments being an infringement of the plantiffs' patent as amended by their disclaimer. Mr. Hemming, Q.C., and Mr. Goodeve, for the company, undertook not to use or sell (as to Wells's instruments sent to use in this country) any Hunnings instruments not protected by the *fiat* of the Attorney-General until trial or further order, and thereupon Vice-Chancellor Bacon ordered the motion to stand over to the hearing, and intimated that he would do all that was in his power to expedite the trial.

LIGHTHOUSE ILLUMINANTS.—Baron H. De Worms asked the President of the Board of Trade in the House of Commons on Monday last whether he would explain why, in the letter of Mr. Vernon Harcourt, gas referee to the Board of Trade (printed at page 29 of the parliamentary papers recently issued on the subject of lighthouse illuminants), there were stars signifying omissions; whether those omissions referred to the fact that Sir James Douglass had sold his lighthouse patents to a company for a very large sum of money, and also contained an opinion by Mr. Vernon Harcourt adverse to the merits of the Douglass burner; and whether he would have any objection to print the letter in full.—Mr. Chamberlain was understood to say, in reply, that the particular document referred to by the hon. gentleman was distinctly stated in the parliamentary papers to be an enclosure from the Board of Trade to the Trinity House. It was referred to in that letter as extracts from a communication from Mr. Vernon Harcourt, and it was printed in the papers precisely in the way he had stated. There would be no objection to let the hon. member see the letter in full.

RESISTANCE OF AN EARTH.—An abstract in the *Society of Telegraph Engineers' Journal* of a paper by M. F. Gattinger, says:—"The author is of an opinion that the present method, by using only one comparative measurement, is insufficient, and may lead to error, as, for example, in measuring the earth of a lightning conductor; and he proposes an improved method. Suppose the resistance of the earth, x, is to be determined, two other earths, y and z, are made, which may be of high resistance, so that iron waterpipes and such like can be used. As a rule, the resistances of the copper wire conductors may be neglected, but for very exact measures it should be taken into account. First, the resistance of the circuit containing the two earths x and y is determined—suppose it to be A. Then find the resistances, B, C, of the two circuits x and z, y and z. From the three equations, $x + y = A, x + z = B, y + z = C$, we have $x = \frac{A + B - C}{2}$; or, in words, add the resistances of the two circuits x and y and x and z, and subtract from the sum the resistance of y

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and z, the remainder divided by 2 is the resistance of the earth, x."

Imitation Telegrams.—In the House of Commons on Monday, Mr. Long asked the Postmaster-General whether his attention had been called to the practice, recently adopted by certain persons, of advertising by means of announcements printed in form, and enclosed in envelopes precisely similar to those used by the Post Office Telegraph Department, which communications had been delivered by hand to householders in London in large numbers, and had caused considerable inconvenience; and, if so, whether any means existed, or could be devised, to prevent the use of such colourable imitations of telegrams. Mr. Fawcett, in reply, said:—"My attention was recently called to an advertisement of the kind described by the hon. member, and I may say that on my pointing out to the person responsible for its issue how objectionable such a form of advertisement was, he expressed his deep regret, and promised that he would never issue such an advertisement again. Whenever anything of the kind has been brought under the notice of the Department, and this has not often occurred, a remonstrance has always had the effect of stopping it." Mr. Augustus Harris, the delinquent in this case, writes to the papers to say that he had discontinued this kind of advertisement several days before Mr. Fawcett's communication reached him.

The Lighting of the Strand District.—Mr. Francis R. Reeves, secretary and general manager of the Jablochkoff Electric Light and Power Company, writes:—"With reference to the advertisement of the Swan United Electric Light Company announcing that the Board of Trade have granted to them a provisional order, under the Electric Lighting Act, for the Strand district, permit me, in justice to this company, to state that there is a condition attached to this provisional order that it is to be null and void if, within six months of the confirmation by Parliament of such order, a license be granted to us for the same district, and as such license has been agreed to by the Strand District Board of Works, with whom we are acting in perfect harmony, there is no likelihood of the Swan provisional order ever coming into effect. I may add that so determined are the Strand District Board to carry out their contract with this company that they have decided to oppose in Parliament the proposals of the Board of Trade." The above has appeared in some of our daily contemporaries. This letter involves some considerations with which the general public is, we should say, unacquainted. It is a fact that before applying for provisional orders the large electric light companies agreed as to the districts for which they should apply; and was it not agreed that the Swan Company should have the Strand district? This is but one of a number of questions we should like to see answered.

Thunderstorms.—A violent thunderstorm passed over Kendal and neighbourhood on Friday afternoon, 15th inst., during which the electric fluid struck a mill used in the manufacture of gunpowder, at Basingill, about four miles from South Kendal. The works belong to Messrs. Wakefield and Co., Gatebeck. The gunpowder exploded with great force, and the mill was completely destroyed. The only man working in the building at the time was terribly injured. On the same day at Birch Hey, near Bury, a farmer, named John Haslam, was struck by lightning in a field and instantaneously killed. In Leicester the chimney of a house in Hastings-street was struck and destroyed, but no injury done to the inmates. At Birstall, however, a cow was killed and many trees badly splintered. On the day following the Old Hall at Lumley was struck by lightning, which did considerable damage to the pictures, looking glasses, and windows. Four men, two women, and a lad are said to have been knocked down, but they appear to have suffered no serious injury. At Cairnbrook, four boys standing inside a stable were stunned and violently thrown to the ground, one of them being rendered unconscious for some time, the others suffering paralysis temporarily in their arms and legs. It was subsequently discovered that a yew tree fifty yards distant from the stable had been struck by lightning, and that marks resembling the foliage of the yew tree were imprinted on the bodies of the lads. On Sunday afternoon lightning struck the roofs of several houses in Christchurch, and set fire to the post office, destroying the telegraph apparatus. Painswick Church, near Stroud, was struck on the same afternoon, twenty feet of the spire falling through the roof. A similar accident occurred to the church at Llandinabo, Herefordshire, just after evensong, five children, who were remaining for shelter, being injured, besides considerable damage done to the structure.

The Far West.—A correspondent sends us a copy of the *Fort Wayne Gazette* of June 3, containing a report of a game of base ball by the electric light. The report reads:—"Last night was the occurrence of the long looked-for event that was to make Fort Wayne historic and cause her name to be mentioned wherever civilisation extended. Base ball is the American national game, but it was reserved for this city to be the first in the world to play it at night, and by the rays of an artificial sun. The Jenney Electric Light Company had surrounded League Park with seventeen lights of 4,000 candle-power each, an amount of light equal to 4,857 ordinary gas burners. Reflectors were arranged behind a portion of the lights so as to throw their rays up in the air, that the sky-scraping flies might be seen, while the rest illuminated the diamond. The degree of illumination was such that the game was played well, although an alarming number of strikes were called by Umpire Morrissey. It was also noticed that when the players looked directly toward one of their lamps they often had to shade their eyes with their hats. The audience in attendance was a very large one and although the turnstile registered 1,675 admissions there were at least 2,000 people present; dead-heads and those who crawled over the fence were fully 400 more. The scene when the game was in progress was a brilliant and novel one. The grand stand, crowded to overflowing, was as light as midday, and the elegant toilettes of the ladies showed to as good advantage as if in the full glare of the ball room, and in fact better, for the electric light shows colours the same as sunlight. All around the park was the thick outer darkness, but within was apparently a charmed enclosure where the sun had focused its rays while the rest of the world lay in darkness. In brilliancy and splendour the spectacle was a great success, but as a specimen of ball playing it was a very poor one." A note appended to the report says the electric light company netted over 300 dollars.

History of Modern Dynamo-Electric Machines.—An abstract of a paper by A. von Waltenhofen, in the Institute of Civil Engineers' *Transactions*, reads as follows:—"The author considers the modern dynamo-machine to be the outcome of the Pacinotti continuous induction-ring armature and Werner-Siemens principle of mutual accumulation, but the question arises as to whom the merit of combination is due, and this appears to have occurred to Professor Pfaundler, of Innspruck, in 1867. While Jacobi (1840) furnished the basis of a theory of electro-magnetic motors, Grove (1844), Joule and Scoresby (1847) and Petrie (1851) must be accredited as those who have given exact information concerning the effective work of these motors. Petrie can alone

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be regarded as having given reliable data, and is also the only one who expressly states that he has taken into account that the theoretical work effected in proportion to the unit of weight of zinc depends upon the nature of the circuit in which the consumption of zinc takes place. The author considers the method of arriving at the weight of zinc consumed by weighing the plates before and after the experiment to be clumsy and inaccurate; and in his own researches has taken the measurement of the current by the tangent-galvanometer, and reckoned, from the product of the current and the known electromotive force of the battery, the effective work in kilogrammetres per second, and, by comparison of the effective work so determined with the work measured with the brake dynamometer, deduced the efficiency of the machine. Let J be the battery current in the motor when stationary, and $J - i$ the current during working of the motor, i being the counter-current induced, λ the total resistance of the circuit; then $J \lambda (J - i) = i \lambda (J - i) + (J - i)^2 \lambda$. The first term represents the current work given off from the battery when the motor is driven, or the total work D; the second, the mechanical work performed in the machine, comprised of useful work and friction; and the third, the heat-work in the circuit. The efficiency is as N : D. To find D the author employs the galvanometer to measure $J - i$, the other factor, or the electromotive force $J\lambda$, being given."

Gas v. Electricity.—The correspondents of the *Gas Journal* hailing from Scotland frequently make some pungent remarks when opportunity occurs upon the electric light, and, of course, always in favour of gas. Sometimes, however, the logical conclusion arrived at by a calm consideration of the facts is just the opposite to that intended by the writer. The following appears in the *Journal of Gas Lighting*:—"Aberdeen, Dundee, and now Perth have given ample evidence that gas is at present in greater demand than ever, despite the efforts of those who consider it a duty to humanity to vilify its use as a miserable illuminant and as a rich air polluter. Whatever influence such misstatements may have upon the popular mind at the moment of utterance, they are quickly effaced by actual facts; and, furthermore, the education which is given by gas companies and corporations to consumers as to the best methods of burning gas, the most suitable apparatus to employ, and the many purposes to which it can be applied, hitherto undreamt of by those not specially interested in the industry, have already had an awakening power, and the gas-burner quack, as well as the electric light enthusiast or greedy speculator, has a far more difficult task before him now than formerly in defrauding the public. In the city of Perth, the Gas Corporation have had their own share of troubles, arising out of the action of certain electric lighting agents who did their utmost to secure certain of the large consumers through promises of success which with existing machinery they could never perform; and not only have the commissioners succeeded in surmounting the difficulties which beset their path a year or two ago, but they have so improved and developed the works under their control that they are able to give gas to the community at such a low price as was, I daresay, thought impossible at the outset of their career." Will not the reader who looks between the lines perceive that great efforts have been made to lower the price of gas and to increase its efficiency because of the fears aroused by the advent of electricity. The users of gas in Perth have witnessed, we believe, a fall of 8d. per 1,000 feet in price within two years, and if the fear of competition with electricity had done nothing more than cause this reduction, the result would be a welcome one.

Cables.—The *Journal Télégraphique* for May 25 gives a table of the existing cables, the date when the cables were laid, their length, the number of wires per cable, the total length of wire, and the nature of the service for which the cables are used. We summarise this list:—

I.—*Cables belonging to various Governments.*

		Naut. miles of cable wire.	Naut. miles of wire.	No. of cables.
Germany	has	436·19	1042·24	32
Austria	,,	97·49	103·97	29
Denmark	,,	111·63	410·18	32
Spain	,,	129·10	129·10	3
France	,,	2329·273	2345·273	41
Great Britain	,,	576·194	1528·163	92
Greece	,,	104·60	104·60	13
Italy	,,	250·29	262·00	15
Norway	,,	245·76	245·76	224
Belgium	,,	40·70	61·81	14
Russia	,,	201·80	209·84	5
Sweden	,,	58·60	58·60	7
Turkey	,,	330·66	333·66	12
Indo-European	,,	1707·00	1707·00	5
India	,,	36·35	36·35	2
Japan	,,	55·498	103·368	11
Russia (Asiatic)	,,	70·017	70·017	1
Australia	,,	43·50	43·50	2
New Caledonia	,,	1·00	1·00	1
India (Dutch)	,,	54·91	54·91	1
New Zealand	,,	196·315	284·940	3
Canada	,,	200·00	200·00	1
Totals		7276·927	9336·281	546

II.—*Cables belonging to Private Companies.*

Company.	Naut. Miles.	Naut. Miles.	No. of Cables.
Submarine Telegraph Company	803·69	3728·64	10
Vereinigte Deutsche Telegraphen-Gesellschaft	1119	1794	2
Hamburg-Helgolander Telegraphen-Gesellschaft	32	32	1
Direct Spanish Telegraph Company	699·13	699·13	2
Mediterranean Extension Telegraph Company	198	198	3
Black-Sea Telegraph Company	350	350	1
Indo-European Telegraph Company	8	24	1
Great Northern Telegraph Company	5916	6142	17
Eastern Telegraph Company	16814·85	16859·85	49
Eastern and South African Telegraph Company	3858	3858	4
Eastern Extension, Australasia, and China Telegraph Company	11265	11265	15
Anglo-American Telegraph Company	10437·56	11035·70	15
Direct United States Cable Company	2983	2983	2
Compagnie Française du Télégraph de Paris à New York	3409·34	3409·34	4
Western Union Telegraph Company	5537	5537	4
Brazilian Submarine Telegraph Company	4296	4296	4
Cuba Submarine Telegraph Company	940	940	3
West India and Panama Telegraph Company	4119	4119	20
Western and Brazilian Telegraph Company	3801	3801	9
River Plate Telegraph Company	32	64	1
Mexican Telegraph Company	709	709	2
Central and South American Telegraph Company	3178·11	3178·11	9
West Coast of America Telegraph Company	1698·72	1698·72	7
Totals	82214·40	86721·49	185

Grand Total.

1 Belonging to Governments	7276·927	9336·281	546
2 ,, ,, Private Companies	82214·40	86721·49	185
	89491·327	96057·771	731

Queensland.—Advices from Brisbane, dated April 10th, described the experimental lighting of the Government Printing Offices by the Edison system under the supervision of Major Flood Page. There are wired some sixty electric lights, the majority of them of sixteen candle-power, one of thirty-two candle, and a few of eight candle-power, distributed about the building, and especially over the frames in

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the composing room. The lights were suspended from the ordinary green shades. The compositors say they find the light preferable to the ordinary gas-burners, and there was a marked absence of heat. After the company, among who was the Minister for Public Works, had inspected the interesting machinery in various parts of the building, they assembled in the large composing room to hear Major Flood Page describe the merits of the Edison system of lighting. Major Flood Page said "that he wished to advance a few arguments in favour of the Edison electric light, which his audience had just had an opportunity of examining. There were two distinct kinds of lights—one the arc light, and another the incandescent, or as it was often called, the 'glow' light. The arc light was that great, big, hideous light that everybody detested, which threw great shadows that hurt the eyes, and which all the ladies said made them look pale and deathlike. But there was no lady in the room who would object to stand under the soft glowing light they had there. There was this advantage in the incandescent system—it was very simple, a servant girl could not go wrong with it. There was another point with reference to the Edison system—every light has an independent connection. If they had a hundred lamps they could put out one or fifty or ninety-nine without affecting the other ninety-nine or the fifty or the one. They lasted on an average about a thousand hours without renewing. Another point was with reference to safety. They had seen the newspaper reports of accidents that had occurred through a human body coming in contact with the electric current. There was a certain amount of motive force in some electric systems which would destroy any human being who allowed the current to pass through his body; but he had taken hold of the cable that conducted the whole of the electricity without hurt. There was no possible danger from fire in the Edison system. Of course there would be danger if the cable were badly laid, but if it were laid properly there would be none. He would just cover the globe near him with a handkerchief to prevent the glass from flying about, and break it. They would see that as soon as the light came in contact with the air it went out. Another advantage was that the electricity that was generated by the dynamo machine might also be used as a motive force. He had seen thirty sewing machines worked by it. In isolated places, such as stations in the bush, the machine would be most useful. The whole of Mr. Edison's system was laid underground." A 16 h.-p. Robey engine is used to drive the Edison dynamo at this installation.

The President of the Gas Institute on Electric Lighting.—At the twentieth annual meeting of the institute held on the 12th, 13th, and 14th inst. at the Frith College, Sheffield, the president, Mr. R. M. Paterson, among other things in his inaugural address, said:—"When, at Birmingham two years ago, it was resolved to abandon the old familiar name by which we were then known, an increase of prosperity and national importance was confidently looked for; but, however great may have been the hopes then entertained, it was not anticipated that we should so soon be universally acknowledged as the executive authority of the industry we represent. Such has been the case, through the International Electric and Gas Exhibition lately held at the Crystal Palace. When the directors of that historical building decided upon holding the exhibition, it was natural they should seek for the assistance and co-operation of those who were able to guide them; and, as you are aware, they appealed to your council to aid them in the work of the gas section. There is, in fact, no other representative body to whom they could apply; and, in the interests of proprietors of gas stock (I say it advisedly), it was fortunate our name had been altered, giving a national instead of a personal character to our organisation, and thus pointing us out to them as the legitimate authority to undertake the work. The occasion was a critical one; and if the institute had not been at hand to do that which it was of the utmost importance should be done well, it is impossible to say what disastrous consequences might have accrued to owners of gas property. It is no breach of confidence to say that had we not been appealed to, and had not the gas authorities throughout the country generously responded to the application we made to them for the necessary funds, the gas section of the exhibition would have been a dismal failure. What this would have meant at that juncture, when the advocates and admirers of electric lighting were exuberant in the recollection of their success in the same building last year, is not difficult to conceive. The value of gas property would undoubtedly have suffered, and the public would not have had an opportunity of witnessing the great capabilities of gas, both as an illuminant and as a substitute for solid fuel. The exhibition, so far as the gas section was concerned, was successful in every department: but the work specially undertaken by the committee of the Gas Institute, and notably the lighting of the nave, was eminently so. Up to the time of the exhibition, I believe the public had no conception that gas was capable of so much development; and there is substantial ground for believing that if this exhibition had preceded by a couple of years or so the Electric Exhibition of last year, ruinous launching of gas stock upon the market by timid owners would not have taken place, and the loss that was involved in the electric light scare would have been averted. Perhaps the best evidence of this is to be found in the high quotations of gas stock at the present time, compared with those of a year ago. It may be argued that other causes have operated favourably in the meantime; and that the practical failure of the electric light as a competitor with coal gas has had the most potent effect. But, from a careful review of the case, I am persuaded that the idea of the permanence and suitability of gas with which the exhibition inspired the public has been the chief cause in restoring their confidence in the value of gas property as a sound investment. If, in the end, no other good accrues from the exhibition, this one result was well worth accomplishing; and the Gas Institute may fairly congratulate itself on having been the means of doing such a truly national work in the name of Science, and on behalf of a great and important industry. Three scientific experts have been appointed to thoroughly examine and test the various gas exhibits; and, it is unnecessary for me to take up your time by discussing the subject here, tempting as it is on such an occasion as the present. But, gentlemen, these things are now matters of history. We cannot have an international exhibition on our hands every year; nor is it to be desired. Shall we, therefore, fall back at once into the simpler lines of work which have hitherto engaged our sole attention—namely, that of meeting once a year, in our associated capacity, to read and discuss papers? That meetings of this description are necessary, and that they have been productive of incalculable benefit in the development of the business with which we are connected, a review of the past history of this institute, under its old name, will speedily make patent to the most incredulous. But it will not be denied that we now hold a different position, and that a larger and more comprehensive work may not unnaturally be expected of us in the future, should occasion call for action."

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SOUTH KENSINGTON EXAMINATIONS AND THE TEACHING OF PHYSICS.

BY G. W. VON TUNZELMANN, B.SC.

In teaching any branch of science there are two objects to be kept in view—the educational value of the branch selected, viz., its effect in training and developing the mind of the student, and the value of the knowledge obtained as an end in itself. The latter will probably have the first consideration in selecting a subject, but when the selection is made, whatever be the branch of science chosen, these two objects will merge into one, for a completely satisfactory grasp of the subject can only be attained by such a course of study as will most fully bring out its educational value. It is unnecessary to insist upon the great advantages conferred by scientific knowledge, as these are now universally acknowledged, and, as we are mainly concerned in the present essay with the method of teaching, we may confine our attention entirely to its educational value. It appears to me to be most necessary to press the importance of considering the subject from this point of view upon the attention both of science teachers and of students, as it is the only way of avoiding a danger inherent not only in the South Kensington examinations, but to a greater or less extent in every system of testing knowledge by examination, viz., the danger of looking upon the examination as the end, instead of merely as a test of the knowledge acquired. The author has had the evil effects of this forcibly brought under his notice in many of the papers sent in by candidates for South Kensington certificates in one or other of the branches of natural philosophy. Frequently a whole set of papers from one school will show that the teacher has endeavoured to give his pupils a competent grasp of the subject as far as they have gone, with the result, as far as the examination is concerned, that the examiner is able to assign good marks to paper after paper; and although it will generally happen that some bad papers are found in every batch, they will usually show with perfect clearness that the failure is due to the stupidity and inattention of the learner to his work. Another batch of papers sent in by pupils of a teacher whose only object has been to get a pass will show that, with perhaps a few exceptions, in the case of students who have risen above the bad instruction, and determined to learn what they could, the learners have no grasp of the subject, with the result that the only questions answered are those which have been learned by rote, while a question which requires for its answer the smallest knowledge of real principles brings out a flood of ridiculous nonsense which ensures the rejection of the paper. Such teaching as this does the greatest possible injury to the learner, who, even if he come later under the influence of a competent instructor, will have contracted evil habits of thought which he will find exceedingly difficult to get rid of, and he will very possibly have got the impression that he really has some knowledge of a subject of which he knows absolutely nothing, but which he has learned to talk about in a superficial manner. In this way a boy who would under proper instruction have become an intelligent student may be converted into a pupil of the most unsatisfactory kind that a teacher can have. Teaching of this kind, moreover, defeats its own object, for the greatest care is taken by the examiners to frame the questions in such a way as to require a real, though it may be an elementary, knowledge of the subject on the part of the candidate who desires to pass. In drawing attention to the evil effect of teaching of this kind, generally known as "cram," we do not forget that to the majority both of teachers and pupils it is a matter of considerable importance that they should pass their examination, and therefore we must expect the course of instruction to be laid down on the lines of the South Kensington syllabus. This, however, cannot be regarded as an evil, for the course of study for each of the stages has been carefully drawn up by men of large experience, who are at the same time practical teachers, and has been so arranged as, in their opinion, to give the greatest benefit to the learner. What we would, therefore, urge upon teachers and students is that, while following the course of study sketched out by the Science and Art Department, the one object in view should be the acquisition of a thoroughly sound knowledge of the subjects taken up, and if the course be worked through with this constant determination, both teacher and pupil may be confident, that in addition to acquiring useful and interesting knowledge the examination will be passed with credit to both.

We here take for granted that the student is in earnest, and the teacher competent, for it is impossible for the best teacher to obtain satisfactory results with a pupil who does not earnestly devote himself to his work, and on the other hand it would be absurd to expect a man to teach a subject of which his own knowledge is unsatisfactory. It has been pointed out again and again, and will be confirmed by every experienced teacher, that it is far more difficult to teach beginners than advanced pupils, and requires a more profound, though it may be a less extensive knowledge on the part of the teacher. We cannot expect every teacher of a science class to be versed in all the more recondite parts of his subject, but we may, and indeed must demand that his knowledge should be first hand and not second hand. If the teacher has merely got up the subject from a book, he cannot by any possibility teach it in a satisfactory manner. In the first place, he naturally gives it out as he has received it, and his pupils simply learn a number of statements, of the truth of which they can give no better proof than that the book or their teacher says so. In the second place such a teacher, never having questioned Nature for himself and pondered over her answers, will be unable to meet an unexpected difficulty, or to give his pupils the happy illustrations which will naturally occur to the teacher who is himself a student of nature. It is only when taught by one who has himself sat at Nature's feet and learned something of her ways that the study of physics can produce its proper effect in training the mind of the learner, and give him knowledge which will be useful to him, not merely to obtain a pass certificate, but as a source of future profit and delight. This bringing the mind into contact with fact is what constitutes the great value of science as a means of mental education, and for this purpose I do not think a better branch could be chosen than some portion of physics. Science is reasoned knowledge; it does not consist merely in acquaintance with a series of apparently unconnected facts, nor is it concerned only with methods of reasoning upon the actual facts of nature. Science is the system formed by building up these facts into one great structure, and though this structure is ever growing in extent and developing in detail, in such a manner that it is utterly impsssible for one mind to attempt to grasp the whole in all its marvellous intricacies, yet the intelligent student while devoting his energies to the study of some special part will ever remember that it is only a part of a great whole of which only a small portion is yet within the grasp of man, although even that small portion is far too vast to be mastered throughout by the individual mind, and he will endeavour to study that part which he has selected, not only in itself as if it constituted the whole of the building, but also in its relations to the other parts, upon the elaboration of which other minds are engaged. The science of pure or formal logic teaches us how to reason deductively, how to draw conclusions, but it does not concern itself with an inquiry into the data from which these conclusions are derived. When certain data are given pure logic simply teaches us to combine them in obedience to the laws of thought. Again, the science of pure mathematics starts with a small number of hypotheses of great simplicity, which until recently have been regarded as self-evident, existing in the mind as necessary truths independent of any actual or conceivable experience of the individual or his ancestors, or what Kant called synthetic *à priori* cognitions. Recently the attention of some of the foremost mathematicians of the age has been directed to the nature of these hypotheses, and they have been led to the conclusion that they are simply facts of experience. Lobachewsky, Riemann, Helmholtz, and others have shown that a perfectly consistent system of geometry may be built upon hypotheses differing from those assumed by Euclid, and if one of these other systems were to be really the one applicable to the space in

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which we live, the fundamental hypotheses of geometry, such as "Two straight lines cannot enclose a space," would only appear to us to be universally true because of the smallness of the portion of space open to our observation, just as the surface of the ocean seems to be a level plain so long as we are restricted to a sufficiently small portion of it.

The processes of pure logic are applied to these fundamental assumptions, combining them together to give us fresh results, and as the number of results increases the operations for combining them become more and more complicated. The system of operations thus gradually built up constitutes the science of pure mathematics, which may be compared to an exquisite mill, and new mathematical discoveries, consisting of fresh combinations of operations to be performed upon the original data, may be considered as representing additions to and improvements in the mill work. The study of pure mathematics as usually taught simply instructs us in the manner of using this complicated machinery, while all questions as to how the data are obtained are generally considered to belong to the domain of the metaphysician rather than to that of the mathematician. The study of experimental science, of which we take physics as the type, opens up quite a new line. Here we are brought into contact with the actual facts of nature of infinite variety and diversity of aspect, and this it is, I repeat, which constitutes its great educational value, independently of the actual value of the knowledge obtained, great as that is. The student of physics is not asked to accept his facts upon the authority of his teacher or of a book. He is brought face to face with the experimental demonstrations, and compelled to accept them by the evidence of his senses. If the teacher does his work at all as it should be done the learner is taught to question every statement until Nature herself has satisfied him of its truth. He learns that the attitude of inquiry is the only one which will enable him to grasp those secrets which Nature retains so firmly until the patient inquirer forces her to yield them up. At first he will believe too readily, he will be too prone to draw general conclusions from particular instances without sufficient evidence; but, as he looks at the subject from different points of view, especially if under the guidance of a competent teacher, he will soon find that he has been too hasty, too ready to accept a conclusion without a thorough sifting of the evidence; in other words, too credulous. Through many failures he will gradually learn to regard the same thing from different points of view, and to carefully examine the evidence before receiving any statement or asserting the truth of any conclusion. Again he will find that the actual facts of nature are quite different from our experience of them. To take a familiar example, the physical phenomena producing in us the sensations of heat and light, which appear so different, really differ from each other no more than those which produce in us the sensations of musical notes of varying pitch; indeed, some of the vibrations are capable of affecting both sets of nerves, and so produce the sensations both of heat and light. The difference between the phenomena producing in our sensory organs the sensation of heat and the sensation of the colour red is of exactly the same kind as the difference between the phenomena producing the sensation of the colour red and the sensation of the colour blue. Again, the physical phenomenon is one which the mere sensations of heat and light would never have revealed to us, consisting as it does in the vibratory motion of a certain medium to which the name of luminiferous ether has been given. Whether this motion will produce the sensation of light or the sensation of heat depends simply upon the rapidity of the vibrations. We know that the slowest light-producing vibrations are those which give rise to the colour red, while the sensation of the colour violet is due to the most rapid of these vibrations. But, again, we find, not only that these vibrations produce two totally distinct kinds of sensation in us by affecting two distinct sets of nerves, according to the rapidity with which they follow one another, but we learn that some of these vibrations are able to affect both sets of nerves, and so produce in us the sensations both of light and heat. This gives us a striking illustration of that absence in nature of hard and fast lines of demarcation which becomes more and more impressed upon us as our study of physical phenomena grows more varied and extensive. Another question which will naturally present itself to us with regard to these vibrations is whether they have exactly the same effect upon the nerves of different persons; and if we pursue this inquiry we shall soon find that instead of uniformity there is infinite variety, as is forcibly exemplified in the case of what is known as colour blindness. This affords us an instance of another fact which it is important to bear in mind in the study of nature, viz., that a part of every observed phenomenon depends upon the observer, and we gradually learn by experience how far this factor is constant from one observer to another. We learn that for the different members of our own species this factor is fairly constant in its general character, but that in many instances there are variations in this general constancy as we pass from one individual to another, and therefore that the same fact may be differently recorded by two different individuals who are both perfectly truthful, simply because each of them could only report the result as it had affected his own sensory organs. Such lessons teach us to be diffident, doubting our own conclusions and those of others until the evidence for them has been thoroughly sifted and found to be satisfactory; they teach us to shun all dogmatism, and to refuse to accept any statement or conclusion until it has been fully tested.

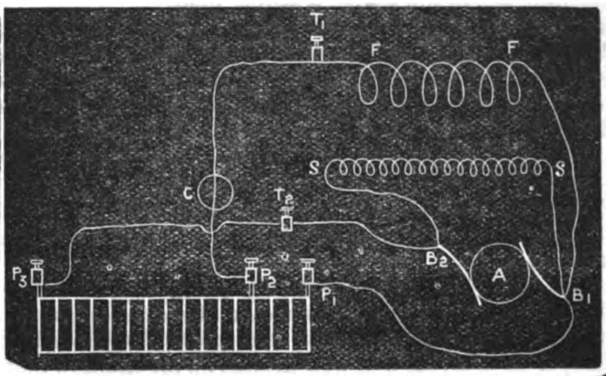
ON A NEW METHOD OF COUPLING DYNAMO AND ACCUMULATORS.

BY GISBERT KAPP.

It is a generally accepted belief that the only way to charge accumulators safely is by using a shunt-wound dynamo. If a series machine be employed, the danger of a reversal of current brought about through the speed of the engine decreasing, or the E.M.F. of the accumulators increasing, is so great that during the time of charging such a plant requires constant watching, or some special cut-out arrangement, which, upon the current weakening, breaks connection with the accumulators before reversal of polarity has actually taken place.

All this is, no doubt, true, if the series machine be connected to the accumulators in the usual manner—viz., the terminals of the one to the terminals of the other; but, by slightly altering this, the complication of a special cut-out arrangement and the danger of reversal of polarity can alike be avoided.

In the diagram (Fig. 1) A is the armature, B_1 and B_2 are



the brushes, F F the exciting coils of the field magnets, and T_1 and T_2 the terminals of the machine.

P_1, P_2, and P_3 are terminals of the accumulators, each terminal having a different potential; and the connections are made as follows:—

B_1 to P_1
T_1 to P_2
T_2 to P_3

Suppose B_1 to be the positive brush, then the potential in

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P_1 is higher than that in P_2, and this again is higher than that in P_3.

$$P_1 > P_2 > P_3.$$

It will readily be seen that with this arrangement the potential in B_1 must always be greater than that in T_1, and therefore the exciting current must flow round the field magnets always in the right direction, no matter what goes on in the external circuit.

The difference of potential in P_1 and P_2 should bear a certain proportion to the resistance of exciting coils (R) and to the external current (C).

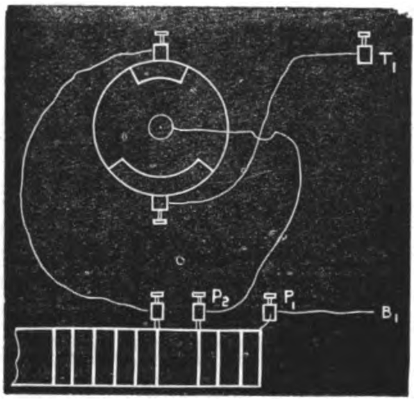
If $P_1 - P_2 = R\,C$, then the cells comprised between P_1 and P_2 will neither charge nor discharge, but as it were simply balance the E.M.F. necessary to drive the current round the field magnets.

If $P_1 - P_2 > R\,C$, the cells will partly discharge, and their discharging current will, jointly with the external current, excite the field magnets.

If $P_1 - P_2 < R\,C$, the cells will get charged; but, of course, at a slower rate than the rest of the battery.

It is best to make $P_1 - P_2$ as near as possible, though not quite equal, R C. For instance, say the machine is designed to give a current of 50 amperes — resistance of field magnets 0·1 ohm, then we would insert two cells between P_1 and P_2, making P_1 and $P_2 = 4·4$ volts, which will nearly balance the 5 volts necessary to drive the normal current round the field magnets.

In point C the special switch, shown in Fig. 2, should be inserted. The centre pin of this switch is connected to P_2, the wide lower contact piece to T_1, the narrow upper contact piece to the positive terminal of the cell standing next to P_2. The two contact pieces are made of different size, in order that the current round the field magnets should always begin to flow a moment before the main circuit is closed, so that the machine starts work with a strong field.



The arrangement above described will be found particularly handy in the case of small electric light installations in private houses, where a gas engine with dynamo and accumulators are employed. Of this I have recently had a striking example in the case of a small electric light installation of about 100 lights, put up in a private house in London by a well-known firm of electric light engineers, the name of which I will, however, not mention here, lest I should be accused of advertising my friends under the guise of a scientific article.

In this case a 3½ horse-power gas engine works a self-regulating machine (shunt coils shown at *s s* in the diagram), and this is coupled parallel with the accumulators and with the lamps. It is a *sine qua non* in such an installation that no skilled electrician should be required to work it, and in this case the duties of the attendant are extremely simple.

To start charging he has merely to turn on the gas to the engine, light the jet and switch on at C. The dynamo will then be driven as a motor by the current from the accumulators (which have sufficient charge left in them from the previous day), and thus cause the gas engine to start. After this the machinery may safely be left to take care of itself throughout the rest of the day, and in the evening, when the maximum of light is required, the dynamo and the accumulators are both feeding into the same lamp circuit.

CORRESPONDENCE.

THE GRAMME RING.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I must ask you to be good enough to allow me to offer some further remarks as to the experiments with a Schuckert machine, alluded to in my last letter, which were made to verify some very similar experiments described by Dr. Higgs in support of his contention that "the cutting of the lines of force may in practice be neglected," as a cause of E.M.F., and that "the inner wire is as efficacious as the outer wire." I prefer to quote Dr. Higgs's own words in order to put the matter clearly. He says:—"I dismounted a Schuckert machine, and causing the magnets to be set up on one side only of the ring, I revolved the ring at constant speed, and put current on to the magnets till there was no increase of E.M.F. I then caused the magnets on the other side to be set up and added; the increase of E.M.F. was about 2 to 3 per cent."

I think I may be excused for having understood this to mean that two poles on one side of the ring produced as great an effect as the usual four poles, minus 2 or 3 per cent.; the statement being put forward, as it was, in support of Dr. Higgs's views as to the efficiency of the Gramme form of machine, with its poles on one side only of the ring. My experiments showed, as I stated in my last letter, that with the magnets on both sides of a Schuckert ring the volt-amperes yielded by the armature were more than 100 per cent. greater than when two poles only were used, and that this proportion was maintained equally with weak and with saturated magnets.

In his letter of last week Dr. Higgs, referring to my remarks and experiments, says:—"When he added the two remaining magnets, he not only doubled his lines of magnetic force, but he also (according to his theory) doubled the wires cutting those lines. Of course, when he added his two remaining magnets, he should have *kept his total magnetism constant*. I am surprised he did not obtain a much greater increase than he reports." A criticism from such a point of view was unexpected. Had Dr. Higgs, in describing his experiments, said that he got about the same E.M.F. whether he used two strong poles on one side of the ring, or four weak ones placed in the usual positions—two on each side—I should have felt no surprise, as this result might have been expected.

But if I had kept the total magnetism constant, and found an equality of effects in the two cases similar to that obtained by Dr. Higgs, I fail to see how the experiments could have been taken to support the contention that the inner and outer wires are equally efficacious, and that "the cutting of the lines of force, considered as a cause of E.M.F., may in practice be neglected."

The experiment seems to show that under no circumstances can a ring armature like that of Gramme, with its poles on one side only, be as efficient as one having both sides exposed to direct inductive action. It points, I think, to conclusions directly opposed to those above alluded to.—Yours, &c.,

June 19, 1883. W. M. MORDEY.

TESTING LIGHTNING CONDUCTORS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I am glad to see another letter on the above subject from one evidently well versed in electrical testing; and I am obliged to him for pointing out three sources of error in my communication to you of the 5th inst. Let me refer to these in their order.

1st. With regard to the resistance of the leading wires from conductor and main water earth to the resistance box—the "tare" let me call it. This was not allowed for in any of the tests I have recorded; for the reason that the wires were very short in the first one, making the resistance to be deducted insignificant. The tare was overlooked in the other two. The wires first used for testing No. 1 are fortunately still in the same position, so that I have been able to examine them. They measure together 33ft. 6in., are gutta percha

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insulated, and have a resistance of ·103 ohm. In testing Nos. 2 and 3 conductors the wires were much longer, but as I cannot now ascertain the length or recover the wires I cannot measure the resistance.

2nd. "A. J." objects to the battery I used. I am sorry I have not a Daniell beside me, and cannot, therefore, make the experiments he proposes; but I do not think the current is flowing long enough at one time to make much difference, especially when we consider,

3rd. That with the galvanometer which I employed (a Silvertown Post Office upright pattern) I was unable to detect any current when the *leaden* and *cast-iron* earths of No. 1 were in circuit with it alone. Neither did it indicate any difference between + and – currents sent through the bridge.

I have examined the copper band round the cast iron-pipes for Nos. 1 and 2 conductors, and find nothing wrong with either of the pipes. No. 1 is in a dry situation, No. 2 is in a well, though not covered with water, both can be easily seen. No. 3 is buried about 20ft. below the surface, and cannot be got at without considerable excavation. When it has done duty for a couple of years I will have it examined.

I am engaged repeating my tests, but have not had time to complete them; when finished I will communicate with you. Meantime, I would like your correspondent "A. J." to give the results of his lightning conductor tests, with the different earths be used; and to explain also for the benefit of your readers what he means by the "*Absolute* resistance in ohms to earth of the lightning conductor."—Yours, &c.,

Greenock, 19th June, 1883. T. L. P.

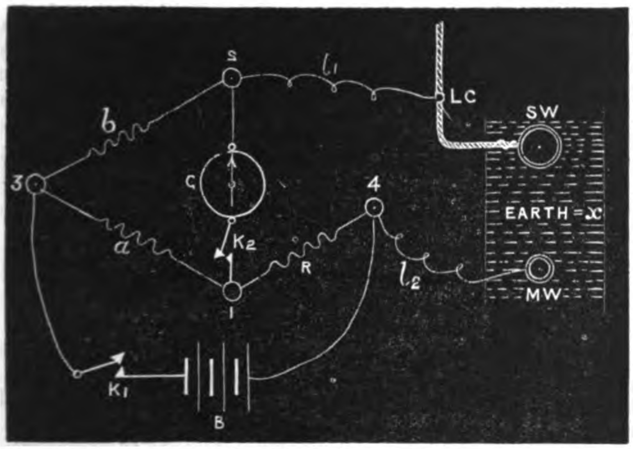
TESTING LIGHTNING CONDUCTORS.

TO THE EDITOR OF THE ELECTRICIAN.

[The following correction arrived too late for insertion in our issue of last week.—Ed. *E.*].

Sir: Please cancel in my letter part *under heading marked* 1, and substitute the following:—

1. Before soldering on his two No. 16 B.W.G. leading wires to his lightning conductor (L.C.) and main water earth (M.W.), he should have joined them together and found their total resistance by the Wheatstone bridge method, and subtracted this amount from the result obtained when testing for the resistance to earth of his lighting conductor in order to find the true resistance between his lightning conductor, earth (S.W.), and the battery earth (M.W.), as seen by the following diagram:—



Where L C represents the lightning conductor attached to
S W „ the cast-iron water pipe,
a and b „ the arms of the Wheatstone bridge,
R „ the resistance required to balance,
l_1 and l_2 „ the leading wires plus the resistance between
M W „ the main water pipe or earth for
B „ the battery, and S W the earth for lightning conductor,
K_1 and K_2 are the keys for manipulating the current, and
G represents the galvanometer.

Now let X equal the resistance between the points 2 and 4 in the above diagram, that is the resistance of leading wire l_1, plus lightning conductor from attachment at (L C) to (S W), plus ground or earth resistance between the pipes (S W) and (M W), plus lead l_2, then when balance obtained

$$a : b :: R : X$$
$$X = \frac{bR}{a}.$$

From X we must subtract the resistance of the leading wires, that is $l_1 + l_2$, in order to get the true resistance from point of attachment at (L C) to the leaden water pipe (M W), *i.e.*,

$$X - (l_1 + l_2).$$

—Yours, &c., A. J.

HISTORY OF TELEGRAPHS.

TO THE EDITOR OF THE ELECTRICIAN.

Sir: In a note in your last week's issue relating to discoveries made by the late Abbé Laborde, reference is made to the "mysterious passage" in the Book of Psalms, "*Fecit fulgura in aquas*," of which the writer gives a lengthy rendering. We are to gather from the interpretation that the author of the Psalms had a scientific knowledge of the subject which has remained hidden from his time to that of the Abbé. I fully believe there are many passages in the Scriptures which will prove that the writers, by inspiration or otherwise, were better acquainted with various branches of science than is generally supposed. Be this as it may, the only passage—at least in the Protestant version of the Psalms—that corresponds with the Latin quotation abovementioned is in the 7th verse of the 135th Psalm, "He maketh lightnings for the rain." Is this the passage referred to by M. l'Abbi Moigno?—Yours, &c., F. S. B.

Charlton, June 18, 1883.

LITERATURE.

Formulaire Pratique de L'Electricien. Par E. Hospitalier, Professeur à L'Ecole de Physique et de Chimie Industrielles de la Ville de Paris. G. Masson, Paris.

Elektrisches Formelbuch. Mit einen Autrauge suthaltena die Elektrische Terminologie in Deutscher, frauzösischer und Englischer Sprache. Von Professor Dr. P. Zech. A. Hartleben. Wien. Pest. Leipzig.

Quite a crop of books containing electrical formulæ are now appearing, but we do not think that the first editions are very promising. We hold that in two necessary features the works before us will fail to satisfy the practical man. Books of this kind should be handy in form, and have a thoroughly good index. Molesworth is far superior in both respects. The work of M. Hospitalier is more comprehensive than that of Professor Zech, including, as it does, formulæ relating to algebra, trigonometry, and other branches of physics, besides electricity. Both compilers seem to have consulted the best text books and publications upon the subject. We should say that both works contain too much letterpress, and that such paragraphs as those on "Procédés d'Aimutation," in M. Hospitalier's work, might well give place to other matter. So far as we have examined these works they contain much that is useful and valuable, and the few words we have said are intended more to suggest improvements in the next edition than to criticise adversely. Let the authors assume that the electrical engineer has some knowledge of electricity, and restrict themselves to the giving of figures and formulæ generally used and not easily remembered. We should have said that a good feature in Dr. Zech's work is the giving in an appendix the nomenclature in German French, and English.

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ON THE DEVIATION OF THE STANDARD COMPASS IN H.M. SHIPS OF WAR.

"The magnetic character of the armour-plated ships of the Royal Navy," was the subject of a paper by F. J. Evans, Staff Commander, R.N., F.R.S., and Archibald Smith, F.R.S., read before the Royal Society in March, 1865.

This paper gave the first published results of the system of observation and analysis of the deviations of the compass then recently introduced. These results showed the magnetic character of a large number of armour-plated ships from the date of launching until they were complete and had been at sea in English waters for some time.

As their longest voyages were to Lisbon and Teneriffe, and the alternative (to a large change of magnetic latitude) of keeling the ship could not conveniently be carried out, the relative proportion of hard and soft iron producing the deviation in their standard compasses could not be ascertained.

It may also be here remarked that none of the compasses referred to in the paper of 1865 had either magnets or other mechanical correctors applied to them.

During the present session of the Royal Society a paper* has been read treating of the relative proportions of hard and soft iron affecting the standard compasses of six classes of Her Majesty's ships, and the changes which take place in their deviations on change of magnetic latitude.

Of the twenty-five vessels the observed deviations of which have been discussed in this paper, six were iron armour-plated, four iron cased with wood, three iron troop-ships, three steel and iron cased with wood, seven composite built, and two wooden vessels with iron beams and vertical bulkheads.

The deviations discussed were observed after the vessels were fully equipped and ready for sea, after long, full-power trials with powerful engines, and consequently to be considered in a state of magnetic stability. Each vessel had also made voyages to places involving considerable change of magnetic latitude from that of England.

Also the semicircular deviation of all these vessels was corrected in England by a bar magnet or magnets fixed in the compass pillar.

From the constancy of the magnetic moment of these correcting bar magnets, they may be considered as the introduction of a permanent and independent magnetic force acting in opposition to the forces produced by the permanent and sub-permanent magnetic forces of the hard iron in the ships.

One of the important results of a knowledge of the constants for soft iron is the power which it gives of predicting for certain vessels examined, and others of the same class, the probable changes which will take place on change of magnetic latitude. Further than this, should it be decided to use a Flinder bar to correct the constant proceeding from induction in vertical soft iron, such a bar could be placed in any of the vessels examined—or those of similar construction—before leaving England, with the reasonable prospect, for example, of the correction being found nearly as complete at the Cape of Good Hope.

Semicircular Deviation.

Semicircular deviation from fore and aft forces is due to three causes:—

(1) A large proportion proceeds from permanent magnetism in hard iron, and may therefore be reduced to zero for all latitudes by a permanent magnet.

(2) A small proportion is caused by sub-permanent magnetism in hard iron. Sub-permanent magnetism diminishes slowly by time, but it is also subject to change from the following causes:—

(*a*) From the ship remaining in a constant position with regard to the magnetic meridian for several days.

(*b*) From concussion.

(*c*) A greater change is experienced from a combination of these causes.

On the removal of these sources of disturbance (*a*) (*b*) (*c*) the deviation gradually returns to its original value.

(3) The principal cause of change of deviation on change of magnetic latitude arises from vertical induction in soft iron, which varies directly as the tangent of the dip. When the compass is properly placed with respect to surrounding vertical iron the deviation from this source is of small value.

Semicircular deviation from tranverse forces is subject to the same laws as that from fore and aft forces, but as the iron is generally symmetrically placed on each side of the standard compass position it is exceptional to find any part of it arising from vertical induction. This part of the deviation, therefore, is chiefly due to permanent magnetism in hard iron, with a small part due to sub-permanent magnetism. It has generally been found that the changes of deviation from sub-permanent magnetism acting in the transverse direction are greater than those in the fore and aft direction.

To ascertain the full value of changes in the sub-permanent magnetism, observations should be immediately taken on the removal of the inducing cause.

Quadrantal Deviation.

Quadrantal deviation, which proceeds from horizontal induction in horizontal soft iron, does not change with a change of magnetic latitude. It decreases, however, during the first year or two after a ship's completion, when it becomes nearly permanent.

It has been found in all modern vessels of war, that the mean directive force of the compass needle is less than on land, generally by about a tenth to the twentieth part, but sometimes attaining a value of three tenths in diminution at the time of launching. It improves slowly by lapse of time, and finally assumes a permanent value.

Relative Proportions of Hard and Soft Iron.

It has been found that the relative proportions of the hard and soft iron affecting the standard compasses of the twenty-five vessels examined differ considerably, even in ships of similar construction.

This difference may be accounted for by the compasses not being placed in the same relative position in the ships considered as magnets of various forms, and containing numerous iron bodies introduced during equipment.

It might have been expected that in those ships in which steel enters largely into their construction, that the deviations would have been less liable to change than in the ordinary iron ship. Such, however, has not been found the case, as the steel used—known generally as mild steel—has only ·2 per cent. of carbon. The conclusions which have been arrived at in this paper point to the conditions which should govern the selection of a suitable position for the standard compass with regard to surrounding iron in the ship.

* "On the Changes which take place in the Deviations of the Standard Compass in the iron armour-plated, iron, and composite built ships of the Royal Navy on a considerable change of Magnetic Latitude, &c." By Staff Commander, E. W. Creak, R.N., of the Admiralty Compass Department. March, 1883.

THE ELWELL-PARKER ACCUMULATOR.

The Wolverhampton Electric Light, Storage, and Engineering Company is now manufacturing and selling a new storage battery, of which very little has yet been heard, but which appears to be one of considerable promise.

About the same time that M. Planté made his remarkable discovery, Mr. Bedford Elwell and Mr. Parker, of Wolverhampton, hit on nearly the same thing. They found that by immersing lead plates in a dilute mixture of nitric and sulphuric acid very important advantages were secured. M. Planté and Messrs. Elwell and Parker patented their inventions about the same time, and now work together.

The method of making the Elwell-Parker secondary battery may be thus described:—Strips of sheet lead 9in. wide and any convenient length, weighing 2lb. to the square foot, are passed through a machine which first punches holes entirely through them and then impresses

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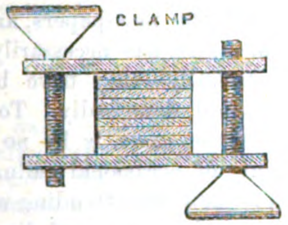
them with indentations, which act as distance pieces to keep the layers of each plate apart. The holes secure a free circulation to the electrolyte. These strips are then rolled spirally into cylinders containing, in the small cells, three thicknesses of plate each, the joints being made secure by fusing with a soldering iron, and an anode of much thicker lead being fused on at the same time. Each cell contains eight of these cylinders $\frac{1}{4}$in. apart. The lead cylinders are first placed in a bath containing a dilute solution of nitric and sulphuric acid, and left there for twenty-four hours. The effect of this bath is to minutely honeycomb the lead plates, putting them into the most favourable condition for "formation" by the electric current. There is also formed upon the surface of the plates a deposit of sulphate of lead, the greater part of which is subsequently reduced to peroxide, part of it being first washed off. The plates on being taken from the bath are washed, and then generally used, but the company manufacturing under the patent also uses wood cells, coated inside with a composition of gutta percha, which are preferable where strength and lightness are required. The quantity these cells will give out at an electromotive force of two volts or rather more—same as the original Planté cell—is about 40 ampere hours when sent from the works, that is, supposing an accummulator is required to give a current at an electromotive force of 45 volts, twenty-two of these cells will give a current of 10 amperes for four hours before any of the cells "give out." But the capacity of the cell may be greatly increased by occasionally reversing the charging current, as in the original Planté cell. The arrangement of the battery is very workman-like and convenient. A cell can be taken to pieces and put together again in about two minutes, and the way in which the cylinders are put together gives great stiffness and prevents deflection or bending, while the plates being free to expand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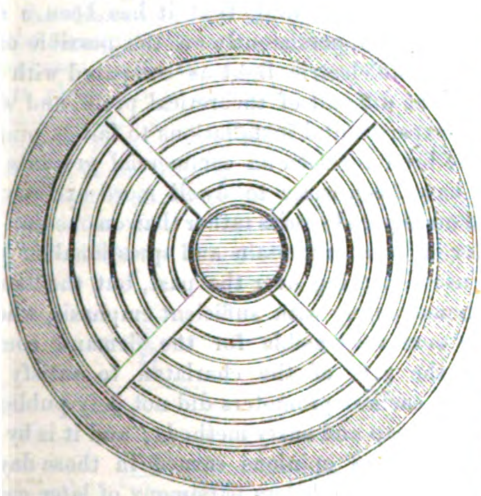
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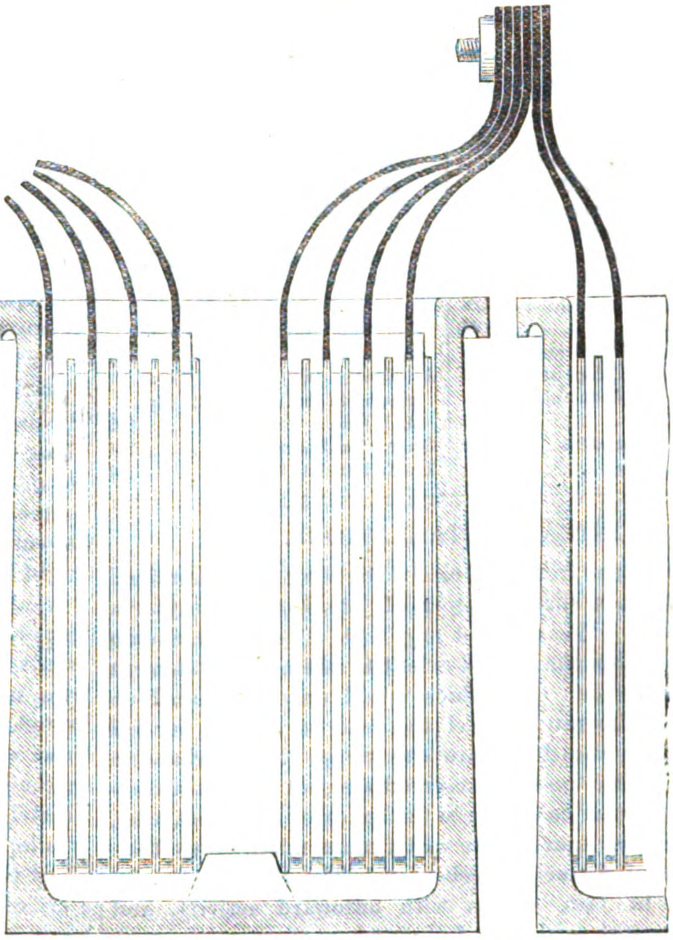
SECTION

placed in the ordinary dilute sulphuric acid solution in the cell. They are then charged in one direction for six hours with a current of 12 amperes, discharged in about three hours through ten Swan 45 volt 20-candle lamps—twenty-two cells give 45 volts—and charged again in the reverse direction. They are then ready for use. There is then no sulphate visible, the peroxide plate being a rich, dark brown colour, of smooth, hard, crystalline appearance, and the negative plate presenting a clean surface of ordinary lead colour.

The accompanying engraving shows one cell and a portion of another, coupled by clamping the electrodes together. The plates or cylinders are retained in position by notched vulcanite frames underneath, and notched distance pieces of the same material on the top, thus leaving the entire space between the plates and a space underneath them open for the free circulation of the electrolyte. Earthenware cells are or contract can do so without losing their shape, which is much more than can be said of most batteries of this class.

The proprietors inform us that last week they took a cell to pieces, one that had been at rest for two months after working regularly for some months previously. They found the plates all clean and smooth, and without a trace of sulphate. The resistance of these cells is extremely small, and no fall is noticeable in the E.M.F. from the first instant of closing the circuit to the time when the first cell "gives out," unless too many lamps have been put in circuit at once. The proprietors state that they have taken out 12 amperes for $2\frac{1}{2}$ hours from a 24 cell battery of this construction without any perceptible fall; and that after a rest of 24 hours they obtained the full E.M.F. again. These cells are now being practically tried with apparently very good results on the Bush Hill Park Estate, near Enfield.

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ANSWER TO CORRESPONDENT.

F. R.—*Have answered you by letter.*

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CHEAP INSTALLATIONS.

The most ardent friends of electric lighting are constrained to admit just now that its career, of late, has been rather a checkered one. We will not say that it is fallen among thieves, for within the limited extent to which that statement might be true our sympathies would only be wasted on people who deliberately travel the road to Jericho in bad company. But the dupes are one thing, the merchandise is another. What we do unreservedly regret is that latterly the new illuminant has got into the hands of hucksters, who, if a degree less knavish, are vastly more mischievous than any number of financial freebooters. The cheap and nasty phase has, in fact, set in with untoward activity, and threatens us with mishap or failure where success might be confidently assured. Cheap machines, cheap appliances, and cheap workmanship are being manufactured or imported in alarming quantities; and nasty exhibitions, futile experiments, and bogus installations are the results. It is not to be wondered at, therefore, that in certain quarters the cry is heard already that the electric light is not only expensive, but inefficient, inadequate, or untrustworthy.

Several causes have been at work to bring about this state of things. First, there is the unwholesome but prevailing tendency to undersell whatever is on the market, and underselling in the case we are considering means, almost of necessity, inferior qualities of one kind or other. Next, there is the undeniable fact that great and perhaps inordinate expectations had been roused in respect to the comparative cost of electric lighting—expectations which, being so extravagant, were doomed to disappointment. Then, again, one after another, fresh systems and appliances have been put forward with inconsiderate haste, whose promises have speedily failed of fulfilment in private, and afterwards more disastrously in public—failed, we mean, in the matter of cheapness, for as regards their performance the public were more than satisfied, they were enthusiastic. Lastly, there was the share market to satisfy or appease. It had opened with the customary programme, and with more than its customary recklessness or ignorance. The result followed that, with a capital commodity for sale, vendors could not find customers except by charging more than their published prices or selling for less than cost.

Then comes the inevitable huckster who undertakes to set matters right by offering a very cheap article. Invention can practise its ingenuity in this direction, of course, as well as in any other, and we are far from saying that the direction of cheapness is one not to be taken when the path leads to efficiency as well. But when cheapness alone is the thing aimed at, as has obviously been the case of late, efficiency will be in inverse proportion to price. Some machines that have recently come under our notice, and have made a great stir in the newspapers, are certainly in this category. The same spirit has necessarily extended itself to the installations generally—they have been done cheaply, and, it is needless to add, done badly. To say nothing of the danger, which in certain cases is by no means imaginary, there is the certainty of occasional failure, and the risk of utter collapse at any moment, attending work carried out in this spirit, and the equal certainty of discrediting the whole business. But the promoters have secured their ends for the time, they have created a cheap commodity, and have found a market for it.

Now, we venture to think that it has been a mistake all along to dwell so persistently on the possible or probable cheapness of the electric light as compared with gas. The contention was difficult of theoretical proof, and was sure in the earlier experimental installations to fail in practice. This might have been foreseen on commercial grounds alone, and it would have been wiser to dwell more exclusively on its many and undisputed merits rather than on one that was, at all events for a time, uncertain and questionable. It is, perhaps, no use lamenting over the past, but the lesson is now brought home, surely with sufficient emphasis, when we see those who were responsible for the demand compelled to descend to the arts of the charlatan to satisfy it. Fortunately, the earliest promoters did not defy public disfavour by adopting cheap and nasty methods; and it is by no means likely that the good opinions earned in those days will be sacrificed by the thoughtless parsimony of later competitors. Their well-deserved failure is certain; the best friends of electric lighting may fervently hope it will be speedy.

One main cause of the vicissitudes experienced by the new illuminant has been due to the public trusting the commercial rather than the scientific adviser. The scientific world is not responsible for the extravagant expectations above commented on, nor for the questionable means adopted to secure the temporary patronage of the public. If promoters and shareholders alike would once for all recognise the fact that this is a scientific subject, and that nobody but men of knowledge and experience are fit to be trusted with the business of electric lighting, there would be an end to accidents, failures, and disappointments. We are sure that no competent scientific adviser would give his countenance to bad machines or scamped workmanship; and the investing public, when invited to embark capital in a cheap concern, would do well to assume beforehand that it will be conducted unscientifically, and is therefore bound to fail.

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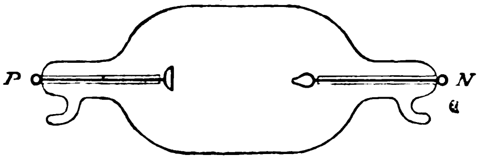
EXPERIMENTAL RESEARCHES ON THE ELECTRIC DISCHARGE WITH THE CHLORIDE OF SILVER BATTERY.*

BY WARREN DE LA RUE, M.A., D.C.L., F.R.S., AND HUGO W. MÜLLER, PH.D., F.R.S.

The authors recall that at the conclusion of the third part of their researches,† they stated that they intended to make an investigation on the dark discharge, and the special conditions of the negative discharge. This paper contains a number of experiments, more especially on the latter subject, and also others intended to throw light on the general nature of the electric discharge through gases.

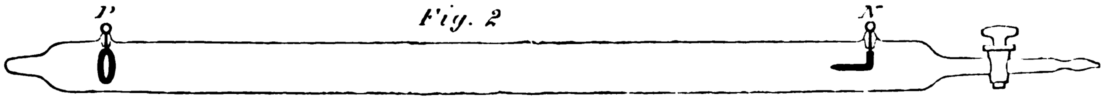
The first part of the paper describes some experiments made with vessels of different forms in order to ascertain whether the dimensions and shape of the vessel have any effect on the pressure of minimum resistance to the electric

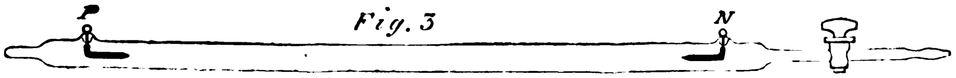
Fig. 1



discharge. This was found to be the case, for example, with a residual air charge in a spheroidal vessel 7in. (17·8 centims.) long, and 5in. (12·7 centims.) diameter (Fig. 1). The pressure of minimum resistance was as high as 3 millims., 3,947 M; while in a tube 22·5 inches (57 centims.) long, and 1·625 inch (4·1 centims.) diameter (Fig. 2) it was only 0·69 millim., 908 M. Again, in a smaller tube 23 inches (58·4 centims.) long, and 0·75 inch (1·9 centim.) diameter (Fig. 3), it was 1 millim., 1,316 M. It is evident, therefore, that not only the dimensions of the tube, but possibly also the shape of the terminals, have an influence on the pressure of least resistance, and it is very probable that in the atmosphere where lateral expansion is practically unlimited, the conditions of minimum resistance are different from those which exist even in very large tubes, and that this may influence the height of the aurora.

The paper next deals with the discharge in miniature tubes $\frac{7}{8}$ inch (2·2 centims.) long, and $\frac{1}{4}$ inch (0·63 centim.) diameter, with terminals nearly touching (Fig. 4). At first it



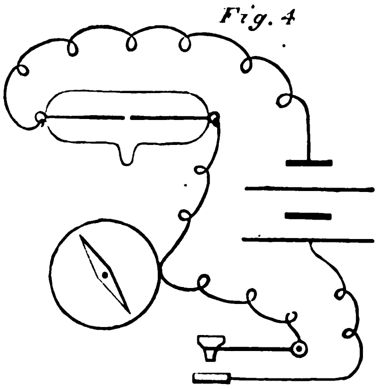


required 2,400 cells to pass, then a single cell would do so, but after standing a short time it required 4,800 cells to reproduce a discharge. In another tube 1$\frac{3}{4}$in. (4·4 centims.) long, and $\frac{3}{8}$in. (0·95centim.) diameter, with the terminals distant 0·00104in. (0·0264millim.), it required 2,240 cells to produce a discharge. Then the potential had to be increased to 11,240 cells to do so. Ultimately even this number failed, but after the tube had lain by for some days, 600 cells could pass. It is very possible that the strong discharge in the first instance volatilised a portion of the terminals which were of platinum, and that this volatilised metal condensed afterwards, or else that the terminals absorbed the gas so completely as to produce a vacuum too perfect to admit of a discharge taking place; and that, ultimately, sufficient of the occluded gas was again given off to render it again possible.

In connection with the occlusion of gas by terminals, a case is described in which the terminals are of palladium, and the charge hydrogen (Fig. 5). After a few discharges the terminals occluded some of the gas, and when a fresh one was produced, a volatile compound of hydrogen and palladium was given off, especially from the negative, and produced a dense mirror-like coating on the inside of the tube (Fig. 6); this was re-occluded by standing for a couple of days, leaving the tube free, and again given off to form a new mirror-like coating with a fresh discharge; this property has continued since March, 1875.

The paper next describes experiments to ascertain the length of the spark in dry air and in air saturated with moisture. It was found to be practically the same in both cases. With 10,860 cells the mean length of the spark between two paraboloidal points was found to be in dry air 0·45in. (1·1centim.), in moist air 0·447in. (1·1centim.).

Fig. 4



The next subject taken up is the discharge in a tube from two batteries, first in the same, and then in contrary directions. In the tube are two terminals at each end, one pair at opposite ends being enclosed in two short pieces of tube, 9in. (22·8 centims.) long, and $\frac{1}{2}$in. (1·27 centim.) diameter; the main tube being 31in. (95·2 centims) long and 1$\frac{3}{4}$in. (4·4 centims.) diameter (Fig. 7). The various phases of the stratified discharge are represented in an engraved mezzotint steel plate copied from photographs, and show the effect of the one stratified discharge on another stratified discharge produced by a second battery. It is seen that two discharges in contrary directions may take place in the same tube, and that the one modifies the aspect of the other.

Experiments are also described in a tube in the form of a cross with four arms at right angles (Fig. 8), with two separate batteries connected in various ways with the different members. The experiments were made both in air and in hydrogen. By the introduction of external resistance in one of the batteries, the discharge could be readily identified as belonging to that battery by the effect of the resistance on

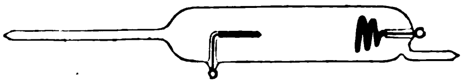


Fig 5.

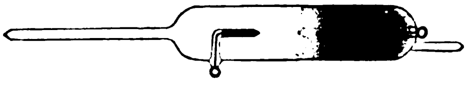


Fig. 6.

the character of the stratification. In one of the mezzotint plates are several figures copied from photographs which show clearly the phenomena produced. Calling the poles P and N of one battery, A, and P′ and N′ of the other, B, it is shown

* Abstract of a Paper to the Royal Society.

† *Phil. Trans.*, Part I., Vol. 171.

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in one case when two currents were equal, 0·0083 ampere, that a discharge from A battery goes from P in the direction of N only so far as the junction at the cross and then turns off to N′, the negative of the other battery B; while, on the other hand, the discharge of the B battery goes from P′ to N of the A battery. The case is different if an external resistance is introduced in one of the discharges, reducing it to 0·00087 ampere, then the discharge of the A battery goes from P to N, and that of the B battery from P′ to N′. There is a bending down, however, of the strata of the weaker discharge at the cross junction, in consequence of the action of the stronger one.

The authors remark that one cannot but be impressed, from the experiments described in the paper, and others in their former papers, by the apparent plasticity of the aggregate assemblage of molecules constituting a stratum which yields to external influences that modify its form.

The authors describe and figure a case of complex strata in the form of an outer bracket convex towards the negative, and close to it an inner chord; also discharges in various gases in tubes of large dimensions, 37in. (94 centims.) long and $5\frac{13}{16}$in. (14·8 centims.) diameter. In these the stratification, which is comparatively narrow at the terminals, extends in a conical form from the terminals to the full diameter of the tube.

They have found that the dark space in the discharge in vacuum tubes is only relatively actinically dark in comparison with a stratum, and they succeeded in obtaining a photograph of the dark space in thirty-five minutes as strong as that from a stratum in two and a half seconds; consequently, they conclude that the dark space is 840 times less actinically bright than a stratum.

The authors next describe a number of experiments, by means of a Thomson-Becker electrometer, used on a method, to avoid leakage, proposed to them by Professor Stokes, to ascertain the difference of potential in different parts of a vacuum tube having a number of rings sealed within it, also in other tubes of special construction. These bring out instructive information, not only in reference to the relative resistances of different lengths of a column of gas at various pressures, but also bring out forcibly the impediment presented by the terminals themselves to the passage of a discharge from gas to terminal and terminal to gas.

It is shown that, at moderate exhausts, the resistance to the passage of the discharge is uniform along the length of the column of gas, and that at high exhausts it is not so, and that the total resistance increases but slightly with an additional length of the column; moreover, that at these low pressures the main impediment is in the passage of electricity between gas and terminal or terminal and gas. This is much greater at the negative than at the positive terminal.

The authors have next studied the electrical condition of a gas in the immediate vicinity of the negative terminal. In order to do this they constructed a tube 4½ inches (11·4 centims.) long, and 1⅞ inches (4·8 centims.) diameter. One terminal is in the form of a point, the other in the form of a ring. The positive pole of the battery was connected with the point and the negative either to the ring or to earth. The ring terminal of the tube was, when the battery was insulated, connected with earth either by means of a stout wire or three feet (91·4 centims.) of fine platinum wire 0·002in. (0·005 centim.) diameter, and offering a resistance of 81 ohms, or a moistened cork offering a resistance of 4,300,000 ohms. In the tube were sealed three idle wires, 1, 2, 3, covered, with the exception of their extremities, with fine glass tubing (Fig. 10). No. 1 idle wire is 0·02in. (0·005 centim.); No. 2 0·2in. (0·5 centim.); and No. 3 0·6in. (1·5 centim.) from the ring. The ring terminal, when connected to earth, was found to be always at zero potential. Notwithstanding this there was frequently observed, more especially as the exhaust was increased, a negative potential when the idle wires were connected successively with the electrometer, amounting in one case with an air charge, pressure 0·01 millim., at wire No. 2, to 1,068 cells, at wires 1 and 3 to 912 cells. At other times a plus potential was observed. Many experiments were made to determine the precise conditions which developed a negative potential or a positive potential, but unsuccessfully, and it was inferred that this depended on the condition of the discharge itself within the tube. It is certainly very remarkable that while the potential of the negative ring was absolutely zero, that a high negative potential should be developed in its near vicinity.

The authors remark that every one familiar with the appearance of a stratified discharge will have noticed, when the negative terminal is a ring, that as the exhaust proceeds a spindle of light approaches, and at last protrudes through

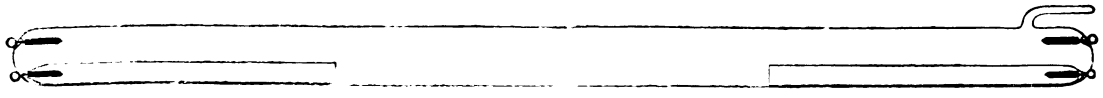

FIG. 7.

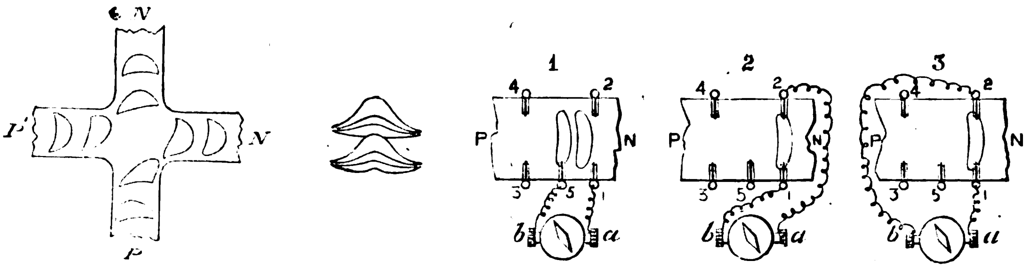

FIG. 8.

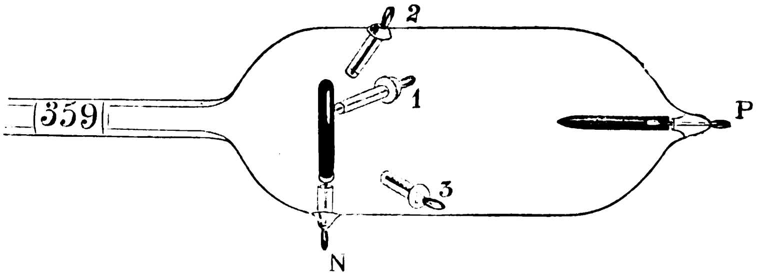

FIG. 10.

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the interior of it (Figs. 11, 1, 2, 3, 4, 5). This spindle they regard as a visible exponent of strong action among the molecules of gas composing it. In order to probe its electrical condition, they prepared a tube with a central idle wire, surrounded by a minute glass tube, except its extremity, and projecting to a distance of $\frac{3}{8}$in. (0·95 centim.) from the plane of the ring, which was made negative. Another idle wire was sealed in the tube 0·15in. (0·38 centim.), from the periphery of the ring. As the exhaust proceeded with a charge of carbonic anhydride, the spindle approached the ring, and ultimately protruded through it. It was found that the potential of the central idle wire increased with the exhaust, until it nearly or quite equalled that of the whole tube; while that of the external idle wire was only 0·054 that of the tube.

A great number of experiments were made to test the potential across a stratum *a*, *b*, and across a dark space *c*, *d*, respectively, by two idle wires sealed in suitable positions in a tube, one of which was connected with earth, the other with the electrometer (Fig. 11, 6). The gases used were carbonic anhydride and hydrogen respectively. As a mean of a great number of experiments it was found that when a dark space was straddled, the potential being reckoned 1, then when a stratum was straddled, the potential was 1·243, 1·229.

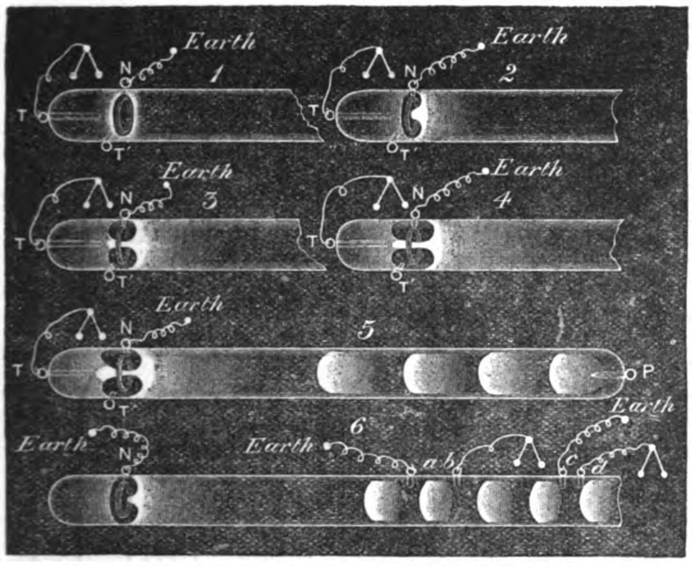

FIG. 11.

On testing two idle wires distant $\frac{5}{8}$ inch (1·6 centim.) apart with a Thomson galvanometer, the current in this fractional part of a tube was found to go frequently in the reverse direction to that of the main current, and when the galvanometer was connected to two idle wires diametrically opposite, currents were indicated sometimes in one direction, sometimes in another, across the tube. These experiments seem to indicate that there are eddies in the gas during a discharge, as if the motion of the molecules conveying an electric discharge was of an epicycloidal character. The authors conclude by saying that it is possible that the eddies may be connected with the production of strata.

PRACTICAL TELEPHONY.

(CONTINUED FROM PAGE 114.)

THE TRANSMITTER.—The instrument principally used in this country is known as the Blake transmitter, which acts by varying the resistance of the local or battery circuit by means of a platinum point pressing against a hard carbon button. The sound waves strike the diaphragm and cause the platinum point to vary its pressure against the carbon button, thus producing undulations in the current strength similar to that described when speaking of the telephone. As the current flowing in the local or primary circuit is much greater than that generated by a telephone, the volume of sound in the receiving telephone is sufficient for all practical purposes; the current of the battery circuit is not, however, allowed to go to line, for reasons to be hereafter explained.

Figs. 22 and 23 show the interior construction of a Blake transmitter. Similar figures or letters show similar parts. A is the mouthpiece forming part of the case, B a cast-iron frame, C an iron lever carried by the spring L and adjustable by screw *d*. This lever carries the spring and brass carbon holder F and carbon button G. It also has attached to it the insulating block H, through which passes the spring carrying the platinum point *e*. This point should follow the carbon button about half an inch if the carbon is pulled back. D shows the diaphragm of thin sheet iron, having on it an insulating rubber ring E. K is a steel spring or damper pressing on the diaphragm D, but prevented from making electrical contact by means of a small rubber glove placed in its extremity. The induction coil is shown at M. The case is hinged at I J. The local circuit through the transmitter is as follows:—The current from local cell enters at terminal 2, passing through primary of coil, the hinge J, wire *b*, frame B, spring L, lever C, spring and carbon block F G, platinum point C, wire *a*, and hinge I, to terminal 1. The telephone circuit enters at terminal 3, passes through the fine secondary wire of coil to terminal 4. The primary wire should have a resistance of about half an ohm, and the secondary about 250 ohms. According to theory the resistance of the secondary should equal that of the line, but in practice it is not always so, for on a line of nearly 1,800 ohms resistance the best effects were produced with a secondary wire of only 30 ohms resistance. The induction coil M, shown in section, Fig. 24, is used because the range of variation of resistance between the carbon button and platinum point would be small compared with the total line resistance, and therefore would give rise to very small undulations in the current, but the same variation produces very great changes in the low resistance primary circuit, and therefore great variations in the current. The secondary current has also the power to overcome a very high line resistance.

TO ADJUST A TRANSMITTER.—In the first place, if it is a new instrument just set up, see that the paper padding is removed from between the carbon block and the frame. Place the telephone to your ear, and tap the diaphragm. A sound should then be heard in the telephone, if connected up rightly. If the sound is dull and short, slacken back the screw *d*. When rightly adjusted a clear, musical sound should be heard, but leaving off sharp. If it seems inclined to be prolonged, or makes a humming noise, the screw must be tightened up a little. Do not at any time move the screw more than a quarter of a turn at a time, or the best position may be passed. If you have an operator at the other end of the line call up and speak. In a well-adjusted transmitter breathing against the diaphragm should be heard, and in a quiet place, speaking in a whisper, should be heard at the other end.

Some allowance should be made for the voice of the person who will usually use the instrument; but, in any case, do not leave the adjustment too loose, or it will jar, and probably commence humming in a few hours, as a newly set-up battery becomes more active as the solution becomes saturated.

THE SWITCH BELL.—It is needless here to go into detail of the various forms of switch bells that have been used from time to time. Those first used consisted of a bell and a switch, which was moved from *ringing* to *speaking* side by hand. This was improved upon by causing the weight of the telephone, when placed on the hook, to hold the switch connected with it in contact with the bell circuit. When the telephone was removed, the hook was drawn by a spring into contact with the telephone circuit, the switch hook itself being in permanent connection with the line.

This form answered all that was required during the time that telephones were used both as transmitters and receivers. The advent of the battery transmitter, however, necessitated an additional arrangement that would automatically open and close the local circuit of the transmitter. After many modifications it assumed the form shown in Fig 25. A B shows the case, C the bell, D the hammer, E E' the magnet coils, F F the iron bell frame, I J K hinges and contact springs (the latter to ensure good connections), L ringing spring, M contact bracket, N battery contact post, O ivory ringing button, P bell contact post, Q switch hook disc, R switch hook, S local circuit contact spring, T' local circuit contact stud, T Z terminal to be connected to zinc of local cell, C terminal for carbon of battery, L do. for line, E do. for earth connection; 1, 2, 3, 4 terminals to be connected to the corresponding numbers in transmitter, 5, 6 terminals for telephone cord; *a* armature to contact spring of bell, *b* adjusting screw for bell, *c* armature, *d' d'* poles of magnet, *e* screw for attaching end of coils to iron frame, *f* contact between M and L (*normal position closed*), *g* contact between L and N (*normal position open*), *h* ivory pin for lifting spring S from contact T when telephone is hung up, *i* bell switch contact spring and post,

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k k′ platinum contact points for *i* and *j*, *m* spring for raising switch hook, *o* screw of switch disc. The passage of the current when receiving a call signal is as follows: (see also small diagrams in Fig. 25) Entering at terminal L, passing to *o*, disc Q, contact point *k′*, spring *i*, hinge I, spring L, contact *f*, bracket M, post P, spring *a*, frame F, screw *e*, coils E E′, hinge J to terminal E. In this position the local cell contact between S and T is open.

In ringing, in reply, or to call attention, the current flows from terminal C to hinge K, post N, contact *g* (now closed by pressing the button O), spring L, hinge I, spring *i*, contact *k′*, disc L, to L and line.

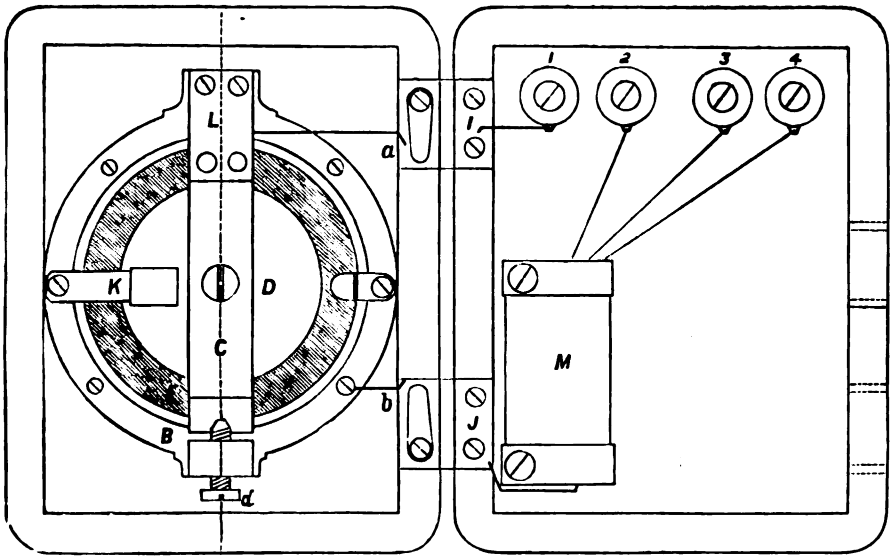

Fig. 22.

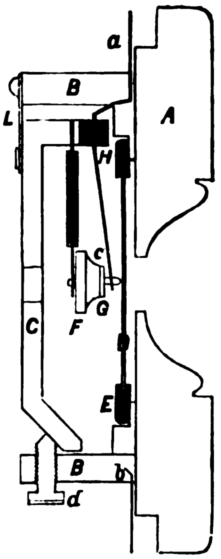

Fig. 23.

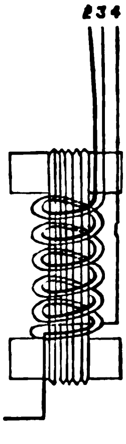

Fig. 21.

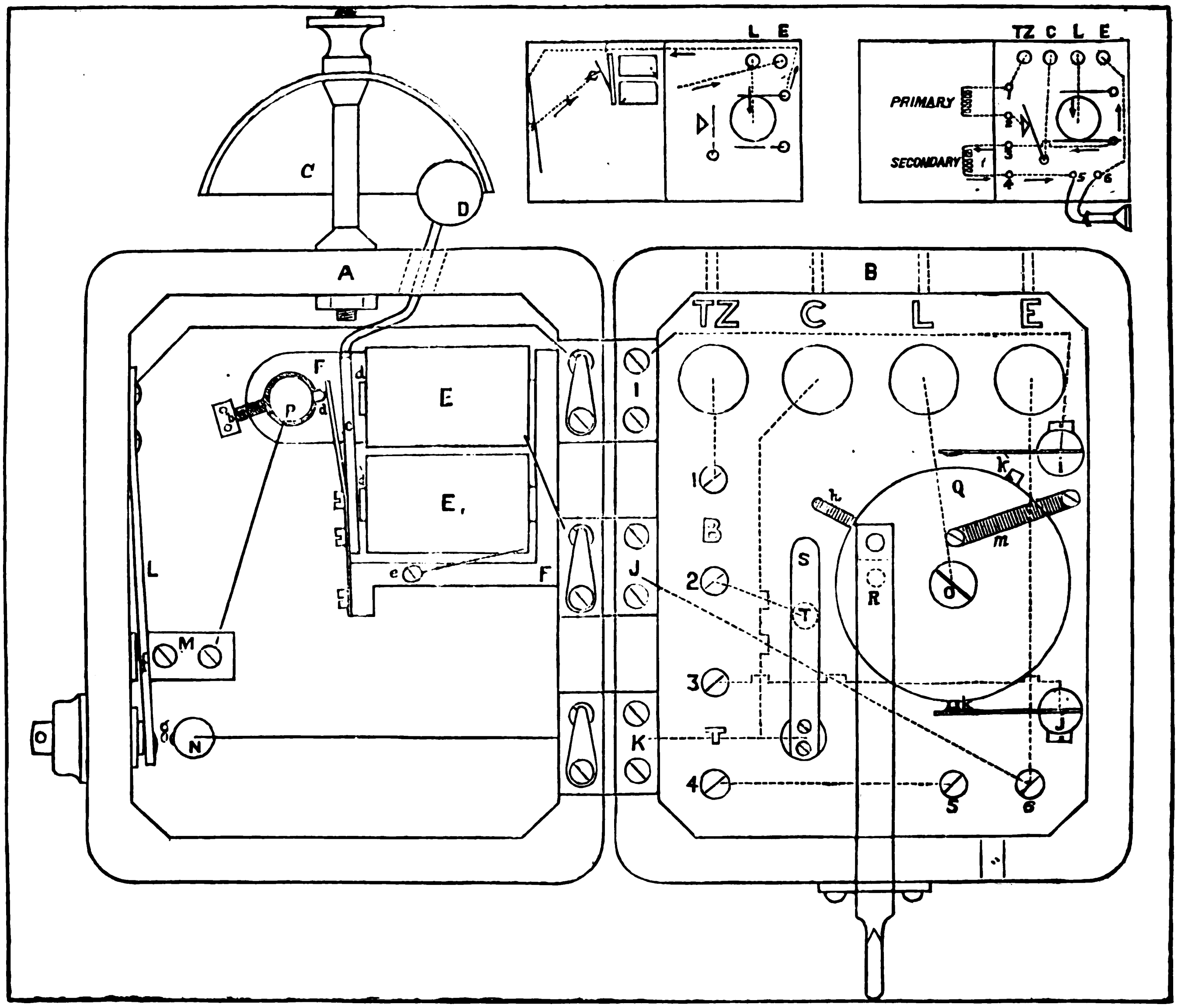

Fig. 25.

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When the telephone is off the hook, the circuits are as follow: the local current flows from C to spring S to contact T (now closed), terminal 2 in transmitter, primary coil, iron frame, carbon button, platinum point to terminal 1 in transmitter, terminal 1 in switch bell to terminal T Z.

The telephone circuit is as follows:—Entering at L, screw *o*, disc Q, contact point K, spring *j*, terminal 3, terminal 3 in transmitter, secondary coil and terminal 4, terminal 4 in switch bell, terminal 5 to telephone, back through cord to terminal 6, thence to terminal E. The letters B and T stamped in the case refer to terminal 1 and 2 and 3 and 4 respectively, representing the local battery and telephone circuits.

In examining a switch bell see that none of the springs are loose, but held firmly by their screws; also see that the necessary contacts are firmly made. Put a little tallow under the spring where rubbed by the ivory pin *h*, but avoid getting any on the platinum contacts.

An improvement in the arrangement for closing the local circuit is now made which has a rubbing contact. The form shown on Fig. 25, being a dotting contact, often causes a fault by dust accumulating and particles of rust falling down from the contact with the ivory pin unless carefully greased. This new rubbing contact, however, unless very firmly made, acts as a microphone, sometimes causing an intolerable noise in the telephone. The slightest touch of sweet oil, however, cures this if the contact is well made.

Switch bells are now made and connected up so that the ringing key will act whether the telephone be on the hook or not. Some of these last-mentioned bells have two ringing keys fitted, one sending a positive, and one a negative current. When two subscribers are connected through the exchange, a polarised communicator is placed in a branch circuit of high resistance, so that subscribers may leave their instruments, and afterwards call each other up by pressing the white left-hand button. This signal passes the central office without dropping any signal plate. When the subscriber desires to be cut off, the right hand black button is pressed, which at once drops the signal at the central office.

MAGNETO SWITCH BELL.—The magneto bell, if well made, is very little liable to faults. The principal fault to which it is subject is in the working of the generator. This may result either from want of oil in the armature bearings or crank handle, or from defective gearing of the two wheels. The bell, when once adjusted, never fails, unless the inducing magnet becomes neutralised by lightning. The telephone hook sometimes works loose by the screw coming out which should hold it in position. This, however, is a mechanical fault that can easily be obviated in new instruments. The peculiar pattern of binding screw adopted by the Americans is particularly liable to work loose unless it is very tightly screwed up. This point should be carefully attended to. A brass screw eye should be placed just under the telephone cord terminal, the cord being passed through and tied in a knot; this prevents the strain coming on the attachment to the terminals. The switch bell is usually mounted on the top of a long back board, under it is placed a Blake transmitter, and at the bottom the box containing the local cell, the top of the box forming a sloping writing desk. The connections for these bells will not be given here, the forms being so various, and instructions are issued by each manufacturer.

(TO BE CONTINUED.)

THE DEVELOPMENT OF ELECTRIC LIGHTING.*

BY J. E. H. GORDON, B.A.,

Manager of the Electric Light Department of the Telegraph Construction and Maintenance Company.

Among all the great industries which in this wonderful last fifty years have been developed, there is none, perhaps, that has had so stormy a birth as the industry which we have met to speak of to-night, namely, that of electric lighting. We must remember that the public know very little indeed about electricity, in fact, nothing. Even in the early days of railways, although there was much ignorance about steam, still everybody had seen a kettle boiling, and had some vague idea of what steam might be even if he did not know what it could do. But the public do not know what electricity is, nor have they any knowledge of its laws; therefore, at one time, they were ready to believe any statements made to them about electricity. Nothing was too extravagant, too startling, or too ridiculous for the public to believe in the early days of electrical enterprise. We all remember that panic in gas shares which occurred about three years ago, when numbers of the public rushed to their brokers, and directed them to sell their gas shares at any sacrifice, to throw them away if there was any liability on them even, but to get rid of them. Why? Because a telegram had come across the Atlantic that Mr. Edison said he had made a discovery which would supersede gas. Few remember that, even with the most perfect discovery, it would at least take a little time to provide for an industry involving a re-investment of capital in England alone of about £100,000,000 sterling, for that is about the amount invested in gas. They imagined this great change was coming instantly. However, this change did not come instantly. Then they said Mr. Edison was an imposter, and that the electric light was a failure, because it was found that we could not undertake to supply one hundred lights when the whole plant was made for the supply of one hundred lights only, at the same rate as one hundred gas lights when they form part of a system supplying, perhaps, one million.

You must not for a moment think that Mr. Edison was to blame for this. Mr. Edison is a genius, and one of the greatest inventors of the age, and he has, in a very high degree, that poetic and prophetic insight which is able to see beyond the trammels of difficulty, and to know in his own mind, for certain, what will come in the future. He saw that the thing could be done, and said so. And, further—it is, perhaps, a failing of inventors, and being an inventor myself I may say it—Mr. Edison, like all inventors, has that enthusiastic imaginative temperament which is necessary for the development of inventive skill, and possibly he may sometimes have slightly confused what he was certain shortly would be done with what had already been done.

Now, this development of electric lighting has suffered to some extent from its enemies, but of course it is understood that gas shareholders are its natural enemies, and will do all they can to retard it; it is perfectly fair and right they should do so. We regard them as fair and open enemies; we are quite willing to fight them on their own ground, and hope the best man will win. But they have not done us much harm—in fact they have done us good. If there had been no other light to fight against, electric lighting would not have developed as fast as it has done. But electric lighting has suffered terribly, not so much from its enemies as from pretended friends. It has suffered much from the operations of persons who, while professing to be interested in electric lighting, and to desire to hasten its adoption, have only been interested in the progress of Stock Exchange operations, and the formation of bubble companies.

Whenever any industry is started which is at all new this will always occur, and the extent to which it occurs is measured, to a certain degree by the credulity, and more by the ignorance, of the public. If companies are brought out in connection with a subject the public know all about, there is not much chance for the public to be deceived, but if it is a subject they know little about, they are easily deceived, and when you come to a subject like electricity, about which the public know nothing, there are special opportunities for the speculator. I hope the ground is now cleared, and that these bubble companies, having satisfied their promoters, are disappearing, and making way for honest, legitimate enterprise to go on.

Now, to turn to the more practical and the more important part of our subject, we have to think what is the problem which has to be solved in the establishment of electric lighting; it is first to provide a perfectly steady, perfectly safe and reliable light, and what is very important still, but which is second, to provide that light cheaply. It is no use getting a light a little cheaper than another, if it is to go out or to blink. Our first consideration must be to make the light perfect, the second, following closely, but still second, must be to make it cheap. This problem must be regarded as a whole, I mean the problem of making it perfect. It has been attacked too much in detail, and the reason of that is that, for success in electric lighting, the knowledge of several branches of science is required, which are not often united in the same person; an electrician, for instance, is very often not a first-class engineer. It is no use getting a little more out of your dynamo if that dynamo will not fit the engine; if you have a certain dynamo that works conveniently with your engine, it is no use making the dynamo one or two per cent. better if the alteration causes you to lose 10 per cent. more in transmitting power to it. You must regard the engines, dynamos, mains, &c., all as one complete system, and you must remember that if anything goes wrong the electric lamps will not make excuses like we may make in the laboratory. They will not say it was not the dynamo's fault, but it was the engine's fault, or the boiler's fault. All that the public would be concerned with was that on this or that occasion the light went out. Therefore we must not despise anything, however foreign it seems to our subject, if it will help to make the system, regarded as a whole, perfect. The electrician knows very well that the principle of a dynamo is to move a coil of wire through a magnetic field, and he is very apt, when he is a pure electrician, to think that he has invented a wonderful dynamo if he gets a coil of wire that will

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go through a magnetic field. He says here is a magnet, and here is a coil of wire, the coil is to be thin and the magnet strong, and the magnet is to be moved fast through that field. Then some outsider says, "How are you going to secure it, and attach it, and support it?" "Oh," he says, "any practical man can tell you that;" but I am afraid that when "any practical man" has found out that, he is apt to patent it and keep it to himself, and sometimes he says that what the electrician has given him is the very smallest part of the invention. Perfecting dynamos is an engineering problem, quite as much or more than an electrical problem.

We must not spend time in going into the details of electric machines, but there are one or two points I may be pardoned for alluding to. It is bad policy to cheapen your system by endeavouring to greatly cheapen the dynamo. The contract price to be paid by a company for electric lighting plant will be one sum for engines, boilers, dynamos, mains, buildings, &c., and it does not matter if the dynamos are a little cheaper, and the engines dearer, so long as the total sum remains the same. But whatever else we economise in, we must not economise in the dynamo; for this reason, that the cost of the dynamo is comparatively a small fraction of the cost of the plant, but the dynamo is the very vital heart and lungs of the whole affair. If anything is wrong with the dynamo, it is no use having the most perfect engines and the most perfect lamps, the lights will go out. Therefore, the dynamos must be perfect, and any economy, any extreme cheapness that is required, must be achieved in some other part of the plant.

Now, this question brings us to a controversy which has been going on, and has been universally discussed ever since electric lighting was first heard of, and which I think will continue to go on for some time, that is, the controversy between the relative merits of high speed and low-speed dynamos. It is necessary in a dynamo that the coil of armature wire should pass at a certain speed through the magnetic field, and that speed can be obtained in two ways; the wire is wound upon a wheel, and you can either have a small wheel which revolves many times a minute, or a big wheel revolving few times a minute, and you get the same speed of the rim in each case. The controversy between high and low-speed dynamos means this: Will you have a small wheel revolving very fast, or a big wheel, revolving very slowly? The first and natural opinion is have a small wheel revolving fast, for you can make the dynamo a good deal cheaper that way; it takes up less space, and altogether seems more convenient. I think every one when he begins electric lighting works approves of high-speed machines. I did myself at one time, very strongly; in fact, less than two years ago, I wrote an article in the *Quarterly Review*, in which, if I recollect rightly, I said the dynamos of the future "will, we believe, revolve much more rapidly than at present; their speed will only be limited by their tendency to fly to pieces." Then my friends and I set to work to build a dynamo on the principles I had laid down in the *Quarterly Review* article. We soon found that in a large, high-speed machine there was a great deal of difficulty in getting the power into it at all. You had to put belts to it, in fact a number of belts and counter-shafts, and there was always a good deal of slipping. Then the belts going at high speed used to make a most terrible noise; there was a deafening roar in the dynamo room, and the whole building used to shake. All these things were bad in themselves, but they were worse in this respect, that all these vibrations, whether of air forming sound, or of the building itself, required mechanical force to produce them, and every bit of that force was stolen from the steam-engine, and taken away from the force that ought to be used in producing light. I suppose this ought to have convinced me that high-speed machines were wrong, but it did not. We went on, we tried a machine, it worked very nicely indeed for an hour, and we got excellent electric results, and were very pleased. Then certain vibrations began to get worse, and I thought it advisable to send the workmen away. There was one safe spot where the person attending the machine was able to stand, from which I was able to watch what happened. The experiment was conducted in a cellar at Wharf-road, all vaulted with brickwork backed by the earth of the street, and it was so hard that when, on some occasion, we wanted to put a spike into it, we were unable to penetrate it at all. After a few hours' work the dynamo flew to pieces with a loud explosion, and I have here some of the few fragments that were left of it. Here you can see the fracture of a massive piece of iron that was caught by it; here are portions of the holders of the revolving magnets. I have not much of it here, the rest of it was picked up in a shovel. The only large piece which was found was a piece which weighed 1½ cwt., which struck the hard wall of the cellar (the distance from the dynamo being about 25ft.), and it cut a hole 2ft. in diameter, and 2ft. deep. Another piece skimmed along the vaulted roof, and made a series of grooves in which you could put your two fists. After that experiment we thought we had had nearly enough of high-speed dynamos—in fact, we thought we had nearly enough of dynamos altogether. Here, perhaps, although it hardly belongs properly to the subject of the paper, I must ask your indulgence if I turn aside for a moment to say a few words of tribute to those friends who, both by their moral and material support, helped me through that very difficult time. After this explosion, when it might have been fairly thought the whole attempt was at an end, my friends met almost among the ruins of the dynamo, and in a few days they subscribed a large sum of money, and said to me, "Go on; build us another dynamo ten times as large as the first, only," they said, "make it strong enough this time." We set to work and built a second machine, and this time we went on very different lines. We made the wheel enormous, and made it run very slowly, taking good care that the whole thing was strong enough. The first machines had taken two to two and a half years to make, the second machine took about eight months, and this was last year, and the experiments cost a great deal of money; one thousand pounds went after another, and still there was no result. Things seemed far from completion, and the money which had been handed to me to build the machine was spent three times over before the machine was finished; still my friends said "Go on, if it costs three times as much as you expected, you must make it do three times as much work." At last we were all ready to try the experiment, and for the last week or ten days I may say we had given up going to bed; it was no use, for we could not sleep; we used to go to bed for two or three hours, but we spent nearly all night in the factory. At last my friend, Mr. Clifford, the Telegraph Construction Company's chief engineer, and myself, began the final trial; we began on the Saturday morning, and thought we should be ready to start the engines on Saturday night; we got the steam up, but first one hitch occurred, and then another, before we could start, and at last it was three o'clock on Sunday morning before we made our first trial. That failed completely; the machine did nothing. We looked over it, and saw what was possibly the cause of error, and set to work to change the connections. Now, if you are changing connections in little dynamos, it is simply a matter of unscrewing two or three screws, and changing the wires, but with this large machine it was not so simple; it took as many men as could cluster over it until six o'clock in the morning; then we got a little better result, and went home for a few hours sleep. We started again early on Monday morning, and at nine o'clock on the Monday evening we were ready for the trial. The experiments were made at the Telegraph Construction Company's Works, at Greenwich, works which are about a third of a mile long, and cover 14 acres; there are 1,200 or 1,400 lights all over the works, and, as the cable department was then busy, there were about 1,000 men at work, and a little glimmering gaslight over each lathe. When I turned the valve the whole place burst into a blaze of daylight at once, and we felt at last rewarded for that three years of anxiety we had had before.

Now, what are the chief advantages of a big machine as compared with a small one. I think the chief advantage of all is that we can dispense with belts. With a big machine we get the necessary velocity by the largeness of the wheel, and, therefore, can cause it to revolve only the number of times in a minute which is not too great for the steam engine to revolve, and can connect direct to the steam engine. Mr. Edison was the first to point out the importance of this, and his was the first very large machine which was made. He has constructed a very large dynamo, which works 1,300 of his lamps, equal to about 1,000 20-candle lamps, his being 16-candle. It has been worked extremely successfully in New York, and also in Holborn; and I will now throw on the screen a picture of it. Then I will show you some of the important points, not of dynamos generally, but of a large machine as compared to a small one. You know that a dynamo machine consists of some apparatus for causing a coil of wire to revolve opposite a magnetic pole, or else magnetic poles to revolve past a coil of wire. In the one you see before you the shaft is geared direct to the steam engine, no belting at all being required. It is driven at the speed of 350 revolutions a minute.

I now come to a very important point, which is, where the current is taken off. Of course, if a current has to be taken from a moving coil to fixed wires, such as the conductors that go to the streets, there must be sliding or rubbing contact of some sort; and you have all seen in ordinary dynamos the contact brush or commutator, and there is always a little sparking. As the current gets greater that sparking gets greater—not proportionately, but still it is greater when you get a large machine. I must say, myself, I think the current for 1,000 or 2,000 lights is about the biggest that can be taken off by rubbing contact; but I never heard that with this 1,300-light machine there has been any difficulty with this. Still, as a matter of prudence, I should not consider it advisable to take enormous currents through rubbing contacts. I am speaking of currents which will supply

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as many lamps as come from our big gas works, therefore when we designed this machine I have been speaking of we arranged it somewhat differently. We used an arrangement which is not new, but was never applied on a large scale before, namely, causing the magnets to revolve and the coils to be fixed. That enables the current, however great, to be taken off without sparking at all, there being a metallic connection the whole way from the fixed coils to the mains.

Here is a diagram of our own machine. This machine has been worked up to nearly 2,000 lights, and we were able to get this off a fraction of the coils, and we have no doubt it will give about 5,000 lights with adequate engine power. We call these 5,000 lights the baby ones. There will be much bigger ones made some day, we hope. There are 32 magnets, which revolve between fixed coils, whence the current is taken off. I must be pardoned in my illustration of big machines for going so much into the details of my own, and so little into the details of the excellent machines of Mr. Edison. My excuse must be, first of all, I am not so well acquainted with the details of Mr. Edison's as with my own; and, secondly, from the natural feeling a parent has for his own child, for he always believes it to be the finest child in the world.

We now come to a requirement which is common to all large machines—namely, a method of adjusting and regulating them while they are going. You see we have to keep the pressure constant, and we have a varying demand. We put on a number of lights when we start, and then somebody turns out a number of lights. Later on somebody else turns a number on, and we have to keep the pressure absolutely constant. Now, with any machine, such as this, if a thousand lights say are on, and another 500 are put on, the pressure will drop, and the 1,500 lights would not be in proportion so bright as the former 1,000. Similarly, if 500 are taken off, the remaining ones would get brighter and break the lamps, and therefore means for compensating for these changes have to be provided. The way in which the regulation is done is by varying the strength of the field magnets. These magnets, which are fixed on the big revolving wheel, are not permanent magnets, but are magnetised by the current of a small direct current machine. At present we use a very good little machine made by Mr. Crompton. This small direct current machine is driven by a small separate steam-engine, and by varying the speed of this small steam-engine, we can vary the strength of the current in the magnets, and so we can alter the pressure just as we want it. Of course we have to alter the pressure according to the requirements of the district, and this is the way the regulation is at present done. The picture on the screen represents the regulating room of our works at Greenwich. First of all we have to see what pressure is right, and for that purpose we employ a photometer, an iron rod which casts two shadows on a screen, one the shadow from a candle and the other the shadow from an electric light further back, the relative distances being so adjusted that the candle-power of the lamp is correct at the moment that the two shadows are equal. By shifting the position of the candles we can work to any candle-power we prefer. The lamp employed being a fair sample lamp, we know that if that lamp is right all the others are right, but we have one or two connected from different parts of the factory, which can be turned on by means of switches. Now, suppose some one at the other end of the factory turns off 100 lights, when there are a large number on, that would not be perceptible in the factory, but the man here can see the change of brightness much more readily than any one can in the open room or yard, and he at once sees that the pressure has run up a little bit. He then turns this valve a little, which partly shuts the tap and diminishes the supply of steam to the small engine, that diminishes the speed and the strength of the magnets, and so takes the pressure down as required. Similarly if 100 lamps are put on he finds the brightness drops, and he has to open the valve, and make his small engine run faster. There is one very important feature which it has been necessary to put into this regulating apparatus, and that is due to the property of the human eye to accommodate itself gradually to changes of light. The pupil of the eye expands and contracts, and takes in pretty nearly the same quantity of light, if the illumination is within certain limits. Although the eye is very sensitive to sudden changes of light, yet if you make the change sufficiently slowly

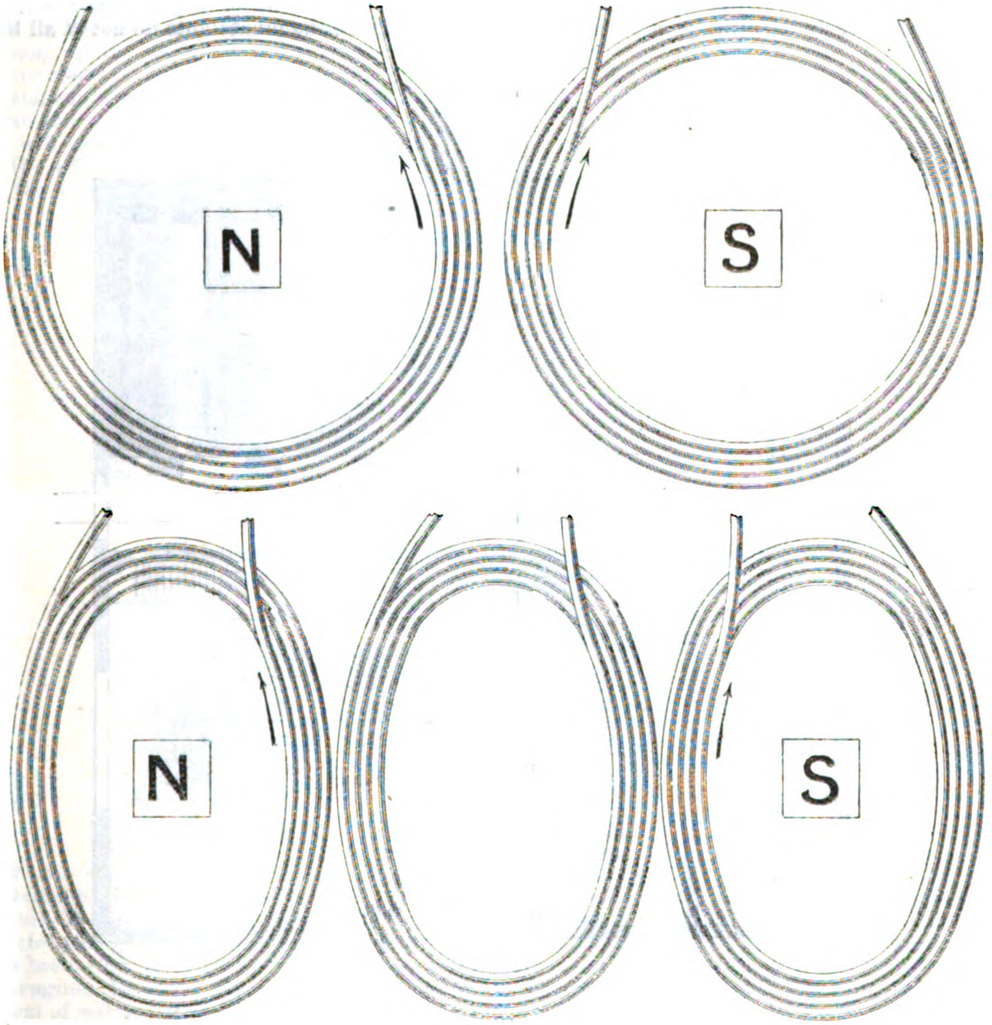

Fig. 1.

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you allow the pupil time to expand or contract, and the change is not noticed very well. Therefore, instead of turning this valve rapidly, it is turned by a slow screw, so that it takes at least a minute to make a change of light equal to one candle-power. The result is that, even if a considerable change has to be made, such a change is never noticed at all. At the back of the room there is a steam-pressure gauge, showing the pressure on the boiler, and an indicator showing the speed of the large engine, and two men stand here on duty in turns all night to work the valve.

You may say that this is an expensive way of regulation, on account of the cost of men's wages; but what we have to consider in the commercial aspect of electric lighting is not the price of working each machine, but the price of working each lamp. It would have been ruinously expensive to have one or two men to attend to a small machine, but when their wages are distributed between 5,000 or 15,000 lamps, it becomes a very small item of expense indeed, although those same wages distributed between 500 or 1,000 would be very extravagant.

There is one small point about this machine, before we leave the technical part of the subject, which I may be pardoned for mentioning; although it is a purely scientific point, I think it is two opposite currents, and we only got the difference between the actual current induced by the magnet, and the back current induced by the next coil. The practical result was that the efficient lighting we got out of the machine was reduced to about one-half. To get over the difficulty, we arranged the machine as shown in the diagram below; we made a number of fixed coils, twice the number of the magnetic poles, flattened them, and squeezed them together, so that each pair of coils was acted on alternately, and between each there was a coil which was not in use at the moment; therefore, although there was a tendency to induce back currents, yet each pair of active coils being separated by an intervening coil, the action was so small as not to be perceptible, and thus the quantity of electricity we could get out of the machines was nearly doubled. We hoped we had now got the dynamo perfect, and that we had solved the problem, and got to the end of our troubles. We had got the dynamo as perfect as we knew how, but we found our troubles only beginning. It is a small portion of the problem of electric lighting to get the dynamo perfect, because there are so many details to be attended to. In putting up a plant for 10,000 lights in the middle of a populous town, a town of wealthy houses, where the inhabitants do not at all like smoke and waste

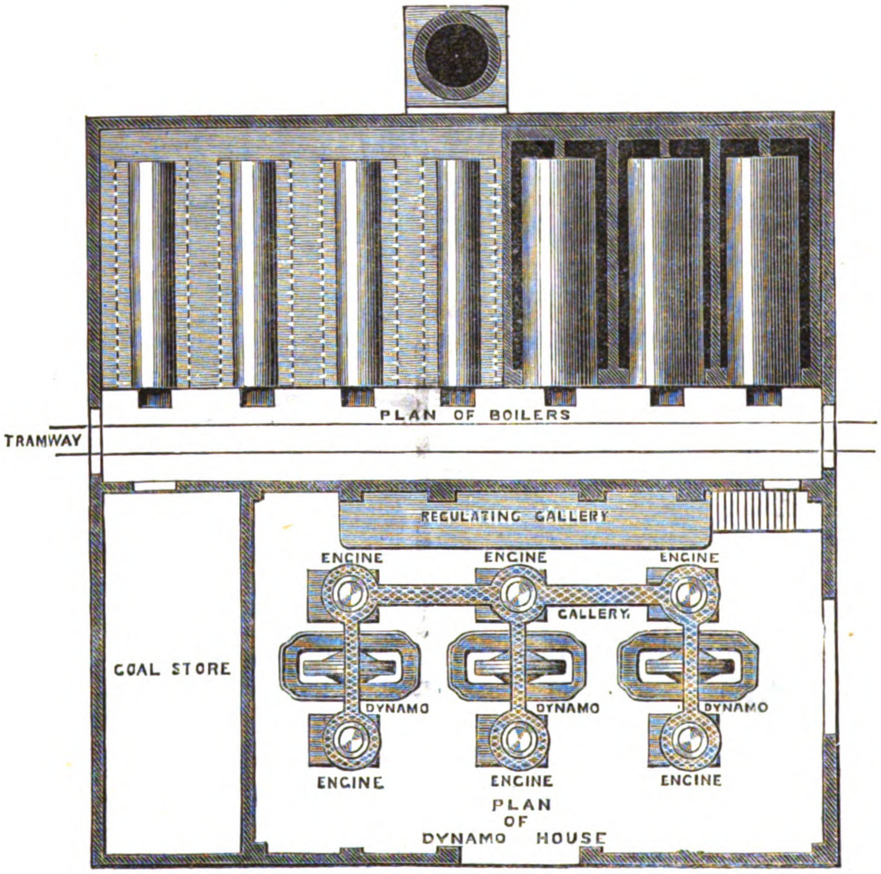

FIG. 2.

of some general interest as showing the kind of difficulties which the designer of any new engineering work has to encounter. In our first model machine we made the same number of coils as there were magnets; that is to say, there were a series of round bobbins in that disc of the machine, and a similar number on the revolving wheel, and currents were induced in the way usual in that class of machine; in fact, the arrangement was something as shown in the upper part of the diagram (Fig 1.) The two centres marked N and S represent the two poles of neighbouring magnets, and these coils represent the coils of wire acted upon by them as they pass, the direction of the currents being the direction shown by the arrows, one going each way. On the first experiment we put one coil on the small experimental machine, and got a good result, but when we put on the next coil alongside we found the mutual action of the two coils pulled down the amount of light produced nearly 50 per cent.; in fact, diminished the power of the machine nearly one-half. A little study of the laws of induction will show you how that occurred. It is a well-known law that a varying current, under certain circumstances, will induce a current in an opposite direction to itself. Here was a current travelling in one direction, which induced a current in the opposite direction, in a neighbouring coil, so that we got steam, there are a great many matters to be attended to. On diagram (Fig. 2) I have shown a plant for an installation for 10,000 lights, which we hope to have the opportunity of putting up soon. This is not the only way, perhaps, not the best way in which it could be worked out, but it is one way which has commended itself to us. There is the plant, an end elevation, and an elevation of the boiler house. Of course, we have to get our boilers in pretty close, there are seven boilers here. Then there is the dynamo house with three dynamos (Fig. 3), each working 5,000 lights, two to be always at work, and one in reserve, the whole plant being designed for 10,000. Then we have an arrangement so that the mains are laid double. That is to say, each house has half its lights from one dynamo and half from another, so that supposing an earthquake upset one of the dynamos and put it wrong, then only half the lights would go out; the town would not be put in darkness. There is one class of accident which may occur to any machine, and it is, I think, about the only difficulty which large dynamos are liable to—that is, getting a hot bearing. But an engine driver is not worth his wages if he cannot keep an engine with a hot bearing going for a quarter of an hour, and supposing he finds he has a hot bearing, all he has to do is to start the spare dynamo, get the

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speed of that the same as the speed on the other, start the exciting engines, get the pressures constant, then pull over the switch, and all that will happen will be a slight jump in the light, and then the engineer may instantly stop the heated dynamo, and attend to the bearing. The engines are condensing engines, each dynamo to have two, and they will require about 510 indicated horse-power when at full work. Each engine is calculated to have a power of 275 indicated horse-power, so as to give about 550 horse-power available, which is sufficient reserve. Again, there are boilers in reserve; 4½ boilers would give sufficient power, so that there will be always two boilers standing quite idle which can be cleaned. There is a large crane running along the roof, which we used to put the machinery into its place, and to lift any part of it as may be required for repairs.

I have spoken of condensing-engines, and I think we must have condensing-engines, at least, in all important and wealthy towns. There are certain advantages of enconomy which are matters quite open to discussion, but I think they are more economical even in London, where water is expensive. We have seen lots of engines for small electric light plants which are not condensing, which do very well, but they have all been small. If you only want 10 or 20, 50 or even 100 horse-power, you may send the waste steam up the chimney, it disappears in the air and you hear no more about it, but if you have over 1,000 horse-power even in this station, which is regarded as a small experimental one, and send the waste steam into the air, two or three unpleasant things will happen. First, you will choke the chimney, because the effect of the steam will be to cake the soot, and so spoil the draught, and some day you would find the furnace would not draw; secondly, that steam would attract all the London blacks and form a fog to which our present fogs would be as nothing, and that would be a bad introduction of the electric light, one of the great arguments in favour of which has been that it is to keep our houses clean. With a condensing-engine, the waste steam is all condensed and goes away in the form of water. It is a hard saying to say there must be condensing-engines, because condensing-engines very greatly increase the first cost, but in spite of this I say we must make up our minds that, if we have the electric light at all, we must be prepared to pay for condensing-engines. We must remember too that there is a special clause in the Electric Lighting Act, and in the draft provisional orders, pointing out that no parliamentary powers conferred on a corporate or other body are in any way to be regarded as a protection to them against being indicted for a nuisance if they should cause one. Therefore we must arrange the plant so as not to cause a nuisance. With electricity there is more loss in transmitting it to a long distance than with gas, so that we cannot place our electric lighting machines at a great distance from the town. About half a mile radius is a convenient distance, and therefore the stations must be tolerably central.

As to the space required, these engine houses, for a 10,000 light plant, require 72ft. square; that is to say, two strips, 72ft. by 36ft. If it were more convenient for the site, we might set the boiler house end to end with the engine house. Then we have to get a supply of coals. We cannot put the coals on with a shovel when working on this scale. We have to think of bringing the coals in through a populous neighbourhood, storing them so as not to cause a nuisance, and feeding them so as not to cause smoke, and also so as not to have an enormous staff of firemen, whose wages would run away with our profits. We may assume at once that we must have what are called mechanical stokers to the boilers; that is to say, that each furnace is fed, not by shovelling in coals, but by a little steam apparatus, by which the coal is discharged into a hopper and slowly screwed into the furnace. That has the advantage that it enables us to burn much cheaper coal than we could otherwise do. We have here a coal store, which will hold about three weeks' winter supply, so that we need only coal about once a fortnight, and we can do it at night. The floor of this coal store is higher than the level of the boilers. The coal waggons will stop outside, there is a small crane by which the sacks are all taken up, the coal is emptied into the store until it is full, and that is the only time the coal is lifted. Near the bottom of the coal store there is a trap-door, and the coal comes out, and is run into trucks running on a raised tramway, and is discharged by its own weight into the hoppers of the stokers. There is, again, a second underground tramway for removing the ashes, so that the coal requires no handling at all.

You may say this is all very pretty, it is a very nice dream for the future, but what is it going to cost? people are not going to buy electric light at two or three times the cost of gas. That is a very important question, and he would be a very bold man who would speak too strongly on the subject, but yet I think we may say not that electric lighting will be dearer than gas, but that it will be almost immediately cheaper. I believe that in the future it will be about two-thirds the price of gas, and I am quite certain that at present it can be supplied in London at the same price as gas, when supplied on a moderately large scale. I have worked out on the table given at end of article some estimates of the capital expenditure and the working cost for an electric lighting plant, and there is not much difficulty in getting out the total expenditure accurately. The doubtful point is what the revenue will be. The two columns show the expenditure of capital and the annual expenses for electric lighting plant of two sizes, one for the supply of electricity to 60,000 lamps of 20-candle power, and the other to 10,000 lamps. In each case we can always count upon putting up half as many more lamps as we should supply, for never more than two-thirds of the total number would be alight at the same instant. First comes the capital expenditure—that is, the price which would be charged by the manufacturers for the whole plant—for machines, dynamos, mains, chimneys, and, in fact, bringing a pair of poles into every house, and starting the concern. Those are not estimated sums; they are taken from tenders which my company has actually furnished to corporations, so we know that the expenditure would not exceed those prices, because we have actually offered to contract to do it for the terms mentioned. The annual expenditure is another matter. It depends to a great extent on the number of hours per annum the lights are burning. I have spoken here of 2,000 hours, but I find there has been a good deal of misunderstanding about what is meant by that. I do not mean that all the lights will burn for 2,000 hours, but what I mean is that the average of the maximum number of lights burning at once will be about 2,000 hours. For instance, suppose in any particular house we put up 30 lamps; there are not, as a rule, more than 18 lamps

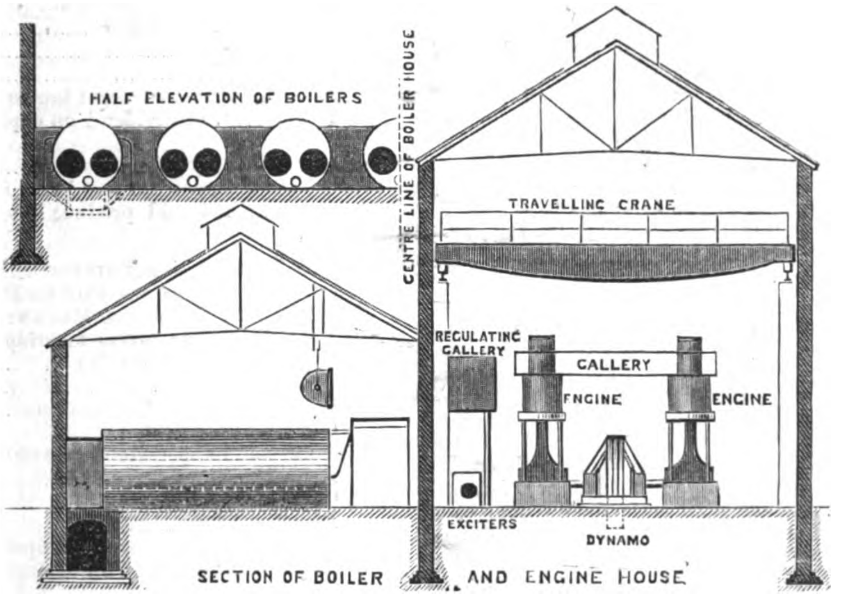

FIG. 3.

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burning at once, and I should not call the expenditure of that house 30 times 2,000 hours, but only 18 times 2,000 hours. We need not provide, in plant, more than sufficient for the total number of lamps likely to be burning at once. I was talking to a gas engineer of very great experience the other day, and he thought I might count on never having more than half the lamps alight at once, but to be on the safe side I have taken it at two-thirds. The number of hours lamps burn depends on where they are. Street lamps burn nearly 4,000 hours; then come clubs, which burn over 2,000, but in private houses they would burn less. I think, with that reservation, that when we are speaking of the maximum number alight at once, and not of the maximum number put up, we may say that 2,000 hours is not very far wrong. Here is the way the expenditure is calculated. Every year put aside something for depreciation. Of course, the first year there would be nothing spent, and perhaps not for a few years, but some day new boilers will be required, and for that we should go on the reserve fund; therefore, each year a certain sum must be put aside for repairs. I have taken that at about £1,500—a certain per-centage on one part of the plant, and a different per-centage on another. It is a large per-centage on the boilers, a smaller per-centage on the dynamos, a smaller still on the mains, and a smaller still on the buildings. When the dynamos are run at a small speed, you can diminish the depreciation on dynamos and buildings; high-speed dynamos shake buildings to pieces before very long. Then comes slack coal at 11s. The consumption of coal has not been guessed at, but is taken by me from figures furnished by Mr. Hill, chief engineer at the Royal Mint. They have lately had a pair of engines, put up by Messrs. Maudsley and Field, of 500 horse-power, about the type of engine we think of using. They are not put up for electric lighting purposes, but for driving the machinery of the Mint; they have been working seven or eight months, and the figures for the consumption of coal are from the actual bills. By using mechanical stokers we can use slack coal at 11s., instead of steam coal at 18s. Mechanical stokers do not give us quite an advantage in the ratio of 11 to 18, because 1lb. of slack coal does not produce so much steam as 1lb. of good coal, but still there is a very great saving in using slack—about 13 to 18. The actual consumption at the Mint has been 2¼lb. of slack coal per indicated horse-power per hour. From that 11s., that item is taken of £1,230. Then there is the water for condensing purposes. Where we get waterside premises that will cost nothing, but in central stations we must reckon 6d. per 1,000 gallons, and a rough and ready rule is that the water costs about the same as the coal when you have to pay for it; and, therefore, I have to put it at the same price. Then oil is a small item, wages and superintendence includes the chief electrician, chief engineer, and various workmen required for small repairs. It does not include any large repairs, which are included in the first item. To be in the dark room, and attend to each engine and dynamo, requires three men always in attendance, *i.e.*, one engine driver, one labourer, and one man in the dark room; each of those works eight hours, so that you require three shifts of men. That makes a man's work 56 hours a week, 54 being the ordinary workman's time. They work, of course, seven days a week. Then there is rent and taxes, interest, directors' fees, and renewal of lamps. These must be renewed free of expense, that is the expense of renewing them must be included in the charge for electricity, whatever it is. I do not mean that if the glass of the lamp is broken it is to be renewed; but when a lamp has been destroyed by the current it is to be removed. When the lamp is broken by the current, the carbon alone breaks, not the glass, and the rule will be when the lamp has broken down, but the glass is intact, it can be exchanged without charge for a new one, but if the glass is broken, it follows it is broken by violence, and must be paid for. The total required revenue, including 10 per cent. dividend, you see is £14,928.

The light obtained from 10,000 20-candle lamps is the same as obtained from 14,000 14-candle lamps burning 5ft. of gas an hour, and they burning for 2,000 hours burn 140 million cubic feet of gas, which produces £15,000, which is the required revenue if gas is charged at 2s. 1¼d., the price in London being 3s. 2d. On the larger want the economy is great. The larger scale we work on the cheaper per lamp will the light be. The light, of course, will have to be supplied by meter, but about that I must postpone speaking to another time.

The introduction of electric lighting has, of course, been attended with many difficulties, but I do not think it has been attended with much more difficulty than must necessarily attend the introduction of any new industry requiring a great re-investment of capital. People who have capital invested in something paying well are shy of taking it out and putting it into something new. If you go to a corporation and say, "If you will spend £100,000 in electric lighting plant you will make a good profit," they will naturally say "That is all very well, but here is the money we are making from gas, and we prefer that;" and then they say, why do not you go in yourselves for this? If it is a good investment, invest your own capital in it, and show us practically it is so. I will not say that is not somewhat hard upon us, but, on the whole, it is a fair enough challenge, and we have made up our minds to accept it. I am not at liberty to say what arrangements are being made, but I hope I shall shortly be able to commence putting up in the West End of London such a plant as we have erected there, and we made an offer to a vestry, in a district in which we propose to put up the lighting, that we will guarantee that the maximum charge for a quantity of electricity equal to 1,000 feet of gas, shall never exceed 3s., and shall be reduced if we can do it. I will not enlarge any more on this, as it would savour very much of listening to a very vague scheme for you to listen to-day to what we propose to do, and it would savour somewhat of boasting for me to say it; but if this society would do me the honour, in about a year's time, to ask me to lecture before them again, then, if our work turns out as I hope and expect, I may be able to tell them not what we hope to do, but what we have actually accomplished.

PLANT TO SUPPLY ELECTRICITY SIMULTANEOUSLY TO 60,000 LAMPS OF 20 CANDLE-POWER EACH, EQUAL TO 85,000 OF 14 CANDLES. CAPITAL EXPENDITURE, £220,000.

Annual Expenditure, Lamps burning 2,000 hours per annum.

Depreciation and repairs	£8,000
Slack coal, at 11s.	7,100
Water, at 6d. per 1,000 gallons	7,100
Oil, &c.	850
Wages and superintendence (63 persons)...	5,390
Rent, rates, and taxes	1,000
Office expenses	500
Directors' fees	1,000
Renewal of incandescent lamps	12,000
10 per cent. of dividend on capital	22,000
Total required revenue	£64,940

85,000 14-candle gas burners burn, in 2,000 hours, 850,000,000 cubic feet, which would produce £65,000, at 1s. 6¼d. per 1,000 cubic feet.

PLANT TO SUPPLY ELECTRICITY SIMULTANEOUSLY TO 10,000 LAMPS OF 20 CANDLE-POWER EACH, EQUAL TO 14,000 OF 14 CANDLES. CAPITAL EXPENDITURE, £50,000.

Annual Expenditure, lamps burning 2,000 hours per annum.

Depreciation and repairs	£1,500
Slack coal, at 11s.	1,230
Water, at 6d. per 1,000 gallons	1,230
Oil, &c.	150
Wages and superintendence (30 persons) ...	2,968
Rent, rates, and taxes	250
Office expenses	250
Directors' fees	350
Renewal of incandescent lamps	2,000
10 per cent. dividend on capital	5,000
Total required revenue	£14,928

14,000 14-candle gas burners burn, in 2,000 hours, 140,000,000 cubic feet, which would produce £15,000 at 2s. 1¼d. per 1,000 cubic feet.

Gas in London is 3s. 2d. per 1,000 feet.

N.B.—It is not expected that each lamp erected will average 2,000 hours per annum, but that 2,000 hours is the average consumption of the maximum number alight at one time. Thus, if a house has thirty lamps, but not more than eighteen alight at once, the average consumption of that house will be 18 + 2,000 = 36,000 lamp hours per annum.

A HISTORY OF ELECTRIC TELEGRAPHY TO THE YEAR 1837.

BY J. J. FAHIE, MEMB. SOC. TEL. ENGS. AND ELECS.*

(CONTINUED FROM PAGE 120.)

His discovery of the dual character of electricity was, like most of the other capital discoveries hitherto made, entirely due to chance. A piece of gold leaf having been repelled by an excited glass rod, Dufay pursued it with an excited rod of sealing wax, expecting that the effect would be the same. His astonishment, therefore, was great on seeing the gold leaf fly to the wax, and, on repeating the experiment, the same result invariably followed; the gold leaf, when repelled by glass, was attracted by resin, and, when repelled by resin, was attracted by glass. Hence

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Dufay concluded that there were two distinct kinds of electricity, and, as one was produced from glass, and the other from resin, he distinguished them by the names *vitreous* and *resinous*.

In repeating Otto Guericke's experiments, Dufay discovered another general law, which enabled him to explain a number of observations that hitherto were obscure and puzzling. This law is, that an electrified body attracts those that are not so, and repels them as soon as they become electric by contact with itself. Thus, gold leaf is first attracted by the excited tube, and acquires an electricity by the contact, in consequence of which it is immediately repelled. Nor is it again attracted while it retains this electric quality; but, if now it chance to light on some other body, it straightway loses its electricity, and is then re-attracted by the tube, which, after having given it a new charge, repels it a second time, and so on, as long as the tube itself retains any electricity (Priestley's "Hist. of Elec.," pp. 40-50.)

The study of electricity was next taken up, in 1737, by Desaguliers, who, though born in France, in 1683, early removed to England, and died in London in 1744.* Two years before his death he published a "Dissertation Concerning Electricity," which is remarkable as being the first book on the subject in the English language. Desaguliers' investigations were mainly concerned with the relative conducting powers of various bodies, but he otherwise did good and useful work, by methodising the information that had already accumulated, and by improving in some important respects the nomenclature. Thus, the labours of Gray, Wheeler, Dufay, and himself, had shown that all matter was divisible into two great classes, these he now proposed to distinguish by the names *Electrics*, or bodies in which electricity could be excited by friction, and *Non-electrics*, or those in which it could not be excited, but which could receive it from an electric. He also first employed the words *Conductor* and *Non-conductor* in the same sense as they are used at the present day.

In the *Philosophical Transactions* for 1739, Vol. 41, p. 209, will be found his experiments on the transmission of electricity, which were made at H.R.H. the Prince of Wales's house at Cliefden, on April 15, 1738. "Having heard that electricity had been carried along a hempen string five or six hundred feet, but having only seen it done when the string was carried backwards and forwards in a room, by silk supporters, Dr. D. wished to try it with a packthread stretched out at full length; for which purpose, having joined a piece of cat-gut to one end of a string, he fastened it to a door; and having also tied another catgut to the other end of the string he fastened it at the other end of the house. At the places where the packthread was joined to the cat-gut he left 18 inches of the thread hanging down, and fastened a *lignum vitæ* handle of a burning glass to one, while he applied a rubbed tube to the other. He made the electricity run to the *lignum vitæ*, but with some difficulty, which he attributed to the sizing, being an animal substance, that still adhered to the thread, as it was new; therefore, he caused the thread to be wet with a sponge from one end to the other, to wash off the size; then was the electricity from the tube communicated very soon and very strongly; for the thread of trial was drawn by the *lignum vitæ* at the distance of a foot.

"Afterwards, having joined more packthread together, he made a string of 420ft. long, which he supported at intervals by pieces of cat-gut. The string was previously dipped in a pail of water, but great care was taken that the cat-gut should not be wet. Then he applied the rubbed tube at one end, while an assistant held the thread of trial near the handle at the other, whereupon it was strongly attracted, though the wind was very high, and blowed in the contrary direction to that in which the electricity ran.

"He first tried the experiment with the packthread dry, but then it would not succeed at that distance."—(Hutton's *Phil. Trans. Abridged*, Vol. 8, p. 357.)

* As a reason for his engaging in this pursuit so late in life, Desaguliers makes the curious assertion that he was debarred from doing so earlier by the peculiar temper of Stephen Gray, who would have abandoned the field entirely if he saw that anything was done in apparent opposition or rivalry to himself. (Brewster's "Edinburgh Encyclopaedia," *verbo* Electricity, page 415.)

It is difficult to reconcile this passage with the following, which we extract from Desaguliers' "Dissertation," page 47:—"Indeed, a few electrical experiments, made by Mr. Gray and myself many years ago, are mentioned in the first volume of my 'Course of Experimental Philosophy,' pages 17-21."

The following lines by the poet Cawthorn depict the neglect and indigence into which Desaguliers fell in his old age—

Can Britain * * * * * *
* * permit the weeping muse to tell
How poor neglected Desaguliers fell?
How he, who taught two gracious kings to view
All Boyle ennobled, and all Bacon knew,
Died in a cell, without a friend to save,
Without a guinea, and without a grave?
"The Vanity of Human Enjoyments."—V. 147-54.

Up to this time, and until some years later, experiments on the transmission of electricity to a distance excited no attention outside a very narrow circle of scientific men, and even amongst these, they served only to illustrate the two great electrical properties of bodies—conduction and insulation—without evoking the slightest suspicion of their practical value. The whole subject of electricity now, however, began to attract general attention, especially amongst the Germans, and the first consequence was considerable improvement in the power and efficiency of electrical apparatus. About 1741, Professors Hausen, of Leipsic, and Boze, of Wittemburg, revived the use of the glass globe machine, first introduced many years before, by Newton and Hauksbee, but which, after their time, had been supplanted, to the great detriment of the science, by the glass tube and silk rubber of Gray. Boze also added, for the first time, the prime conductor, which consisted of an oblong cylinder of tin or iron. This was at first held in position by a man, who was insulated, by standing on cakes of resin, but it was subsequently suspended by silken cords; and, in order to facilitate the passage of the electricity, a number of linen strings were added, which served the purpose, though very imperfectly, of the metal points now employed. Professor Winkler, of Leipsic, next substituted a fixed woollen cushion in place of the hand for exciting the globe, and lastly, in 1742, Gordon, a Scotch Benedictine monk, and Professor of Natural Philosophy at Erfurt, substituted a glass cylinder for the globe, and otherwise so increased the power of the machine, that he was able to kill small birds at the end of an iron wire 200 ells (250 yards) long (Priestley, "Hist. Elec.," pp. 64-67.

These various improvements were followed, in October, 1745, by the discovery of the Leyden Jar. This invention is one of the vexed questions of the science, being claimed, and perhaps with equal justice, for Von Kleist, dean of the Cathedral at Kamin, in Pomerania; for Musschenbröck, the celebrated professor of Leyden; and for Cuneus, a rich burgess of that town. Von Kleist appears to have been first, in point of priority of publication; but his account of the discovery was so obscurely worded, that it was impossible for some time to verify it. The following is an extract from his letter on the subject, which was addressed to Dr. Lieberkuhn, of Berlin, on the 4th November, 1745, and by him communicated to the Berlin Academy:—"When a nail, or a piece of thick brass wire, is put into a small apothecary's phial and electrified, remarkable effects follow; but the phial must be very dry or warm. I commonly rub it over beforehand with a finger on which I put some pounded chalk. If a little mercury, or a few drops of spirit of wine be put into it, the experiment succeeds the better. As soon as this phial and nail are removed from the electrifying glass, or the prime conductor to which it has been exposed is taken away, it throws out a pencil of flame so strong, that with this burning instrument in my hand I have taken above sixty steps in walking about my room. When it is electrified strongly, I can take it into another room, and there fire spirits of wine with it. If, whilst it is electrifying, I put my finger, or a piece of gold which I hold in my hand, to the nail, I receive a shock which stuns my arms and shoulders. A tin tube, or a man, placed upon electrics, is electrified much more strongly by this means than in the common way. When I present this phial and nail to a tin tube which I have, fifteen feet long, nothing but experience can make a person believe how strongly it is electrified. Two thin glasses have been broken by the shock. It appears to me very extraordinary that when this phial and nail are in contact with either conducting, or non-conducting matter, the strong shock does not follow. I have cemented it to wood, glass, sealing-wax, metal, &c., which I have electrified without any great effect. The human body, therefore, must contribute something to it. This opinion is confirmed by observing that, unless I hold the phial in my hand, I cannot fire spirits of wine with it."

In January, 1746, Cuneus made the same discovery, and, apparently, in the same accidental way. It having been observed by Musschenbröck and his colleagues, Cuneus and Allamand, that electrified bodies speedily lost their virtue, which was supposed to be abstracted by the air itself, and by vapour and effluvia suspended in it, they imagined that if they could surround them with any insulating substance, so as to exclude the contact of the atmosphere, they could communicate a more intense electrical power, and could preserve that power for a longer time.* Water appeared one of the most convenient recipients for the electrical influence, and glass the most effec-

* In a paper read before the Royal Society in 1735, Stephen Gray has these curiously prophetic words:—"Though these effects of the fire and explosion of electricity communicated to a metallic rod are at present only minute, it is probable that in time there may be found out *a way to collect a greater quantity of the electric fire*, and consequently to increase the force of that power, which by several of these experiments, if we are permitted to compare small things with great, seems to be of the same nature with that of thunder and lightning."—(Priestley, page 54.)

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tual and easy insulating envelope. It appeared, therefore, very obvious, that water enclosed in a glass bottle must retain the electricity given to it, and that, by such means, a greater charge or accumulation of electric force might be obtained than by any expedient before resorted to. In the first experiments made in conformity with these views, no remarkable results were obtained. But it happened on one occasion that Cuneus held the glass bottle in his right hand, while the water contained in it communicated by a wire with the prime conductor of a powerful machine. When he considered that it had received a sufficient charge he applied his left hand to the wire to disengage it from the conductor. He was instantly struck with the convulsive shock which filled him with the utmost consternation, and made him let fall the flask. Musschenbröck and others quickly repeated the experiment, and with like results (pages 75—8. Priestley's "Hist. Elec.").

In describing these in a letter to Réaumur, Musschenbröck said he felt himself struck in the arms, shoulders, and breast, so that he lost his breath, and was two days before he recovered from the effects of the blow, and the terror. He added that he would not repeat the experiment for the whole kingdom of France. Boze, on the other hand, seems to have coveted electrical martyrdom, for he is said to have expressed a wish to die by the shock, (the name by which this phenomenon was known) that the account of his death might furnish an article for the Memoirs of the French Academy. Allamand, the associate of Musschenbröck, took the shock from a common beer glass, and lost the use of his breath for some minutes, and then felt so intense a pain along his right arm, that he feared permanent injury from it. Professor Winkler, on undergoing the experiment for the first time, suffered great convulsions, his blood was agitated, and fearing an ardent fever, he had recourse to cooling medicines. His wife, also, with a courage only equalled by her curiosity, twice subjected herself to the shock, and was so enfeebled thereby that she could hardly walk, and on trying it again, a week later, it gave her bleeding at the nose.* ("Priestley" pp 78-9)

An account of these extraordinary effects soon got abroad, and spread over Europe with the rapidity almost of the spark itself. The experiments were repeated everywhere, and excited the wonder of all classes towards what was regarded as "a prodigy of nature and philosophy." Indeed, so popular did they become, that great numbers of impromptu electricians wandered over every part of Europe, and enriched themselves by gratifying the universal curiosity at so much per shock.

But as soon as these first feelings of wonder had abated, philosophers set themselves seriously to study the powers of the new machine. The circumstances which influenced the force of the shock first engaged their attention.

Musschenbröck observed that if the glass were wet on the outer surface the success of the experiment was impaired. Dr. (afterwards Sir William) Watson, apothecary and physician, of London, next proved that, while the force of the shock was increased by diminishing the thickness of the glass, it was independent of the power of the machine by which the glass was charged.

By further repeating and varying the experiment, Watson found that the force of the charge depended on the extent of the external surface of the glass in contact with the hand of the operator; and it occurred to Dr. Bevis that the hand might be efficient merely as a conductor of electricity, and in that case the object might be more effectually and conveniently attained by coating the exterior of the phial with sheet lead or tinfoil. This expedient was completely successful; and the phial, so far as related to its external surface, assumed its present form.

Another important step in the improvement of the Leyden jar was also due to the suggestion of Dr. Bevis. It appeared that the force of the charge increased with the magnitude of the jar, but not in proportion to the quantity of water it contained. It was conjectured that it might depend on the extent of the surface of glass in contact with water; and that as water was considered to play the part merely of a conductor in the experiment, metal, which was a better conductor, would be at least equally effectual. Three phials were therefore procured and filled to the usual height with shot instead of water. A metallic communication was made between the shot contained in them respectively. The result was a charge of greatly augmented force. This was, in fact, the first electric battery.

Dr. Bevis now saw that the seat of the electric influence was the surface of contact of the metal† and the glass, and rightly inferred that the form of a bottle or jar was not, in any way, connected with the principle of the experiment. He, therefore, took a common pane of glass, and having coated the opposite faces with tin-foil, to within an inch of the edge, obtained as strong a charge from it as from a phial having the same extent of coated surface. Dr. Watson being informed of this, coated large jars, made of thin glass, on the inside and outside with silver leaf, extending nearly to the top of the jars, the effects of which fully corroborated the anticipations of Dr. Bevis, and established the principle that the force of the charge was proportional to the quantity of coated surface.—("Priestley," pp. 82-7.)

(TO BE CONTINUED.)

COMPANIES' SHARE LIST.

TELEGRAPHS.

Companies.	Closing Prices June 20.		Business Done Week Ending June 20. Highest.	Lowest.
Anglo American	49½,	50	50	49¾
Do. Preferred	81½,	82	82½	81½
Do. Deferred	19¼,	19½	19⅝	19
Brazil Submarine	11¾,	12	12	11⅝
Cuba	10,	10½	10⅜	10⅛
Do. Preference	17,	18	—	—
Direct Spanish	5¼,	5¾	—	—
Do. Preference	15¾,	16¼	—	—
Direct United States Cable	12⅝,	12⅞	12⅞	12⅝
Eastern Telegraph	11⅞,	11⅞	10⅞	10 11-16
Do. 6 per Cent. Preference	13¼,	13⅜	13⅜	13 1-16
Do. 5 per Cent. Debentures, 1899	104,	107	105⅝	--
Eastern Extension	11⅝,	11⅞	12	11¾
German Union	10,	10½	10½	10 1-16
Globe Telegraph and Trust Company	7 3-16,	7 5-16	7 5-16	7⅛
Do. Preference	12¾,	13	13⅛	12¾
Great Northern	12¾,	13	—	—
Indo-European	31¾,	32¼	—	—
Mediterranean Extension	1¾,	2¼	—	—
Do. Preference	6,	7	—	—
Reuter's	9½,	10	—	—
Submarine	247,	252	—	—
West India and Panama	1⅛,	1½	—	—
Do. 1st Preference	6⅛,	6⅜	6¼	—
Western Brazilian	6½,	6¾	6½	6¼
West. Union 7 per Cent. 1st Mortgage	122,	124	—	—
Do. 6 per Cent. Sterling Bonds	103,	106	104½	103½

TELEPHONES.

Consol. Telephone and Maintenance	¼,	⅝	½	7-16
Oriental	7-16,	9-16	9-16	½
United Telephone	10⅜,	10⅝	10 11-16	10¼

ELECTRIC LIGHT.

Anglo-American Brush Lgt. (£7 paid).	3⅝,		3 13-16	3½
Do. (fully paid)	6½		6½	—
Hammond Light	2¼,	2¾	2 11-16	2½
Swan	1½,	1¾	1⅝	—
Maxim-Weston	½,	¾	—	—

MISCELLANEOUS.

Telegraph Construction	33¾,	34¼	34¼	33½
India Rubber, Gutta Percha, and Telegraph Works	30¾,	31¼	31¼	30¼

TRAFFIC RECEIPTS FOR MAY, 1883.

Companies.	May, 1883.	May, 1882.	Incrse.	Decrs
Anglo-American Telegraph Company	—	—	—	—
Brazilian Submarine Company	—	—	—	—
Cuba Submarine Company	3,300	3,544	—	244
Direct United States Cable Company	—	—	—	—
Direct Spanish Telegraph Company	1,638	1,038	600	—
Eastern Telegraph Company	—	—	—	—
Eastern Extension Telegraph Company	32,156	33,087	—	931
Great Northern Telegraph Company	22,600	—	—	—
Submarine Telegraph Company	—	—	—	—
West Coast of America Telegraph Company	—	—	—	—
Western and Brazilian Telegraph Company	—	—	—	—

* It is no doubt to the "uncontrolled use of the imagination in science", that we must, in a great measure, attribute these first effects of an experiment with which electricians are now so familiar, and which every school boy and girl undergo nowadays from motives of curiosity or amusement.

† This question was very beautifully settled a year or two later by the celebrated Benjamin Franklin. He charged a jar, and then insulating it, removed the cork and the wire by which the electricity was conveyed from the machine to the inside of the jar. On examining these he found them free from electricity. He next carefully decanted the water from the charged jar into another insulated vessel. On examining this it was also found to be free from electricity. Other water in its natural state was now introduced into the charged jar to replace that which had been decanted, and on placing one hand on the outside coating, and the other in the water, he received the shock as forcibly as if no change had been made in the jar since it was first charged.—("Priestley," p. 144).

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NOTES.

Honours to Mr. Swan.—In convocation at Durham, on June 26, the honorary degree of Master of Arts was conferred on Mr. J. W. Swan, the inventor of the Swan lamp.

West Coast of America Telegraph Company.—The coupons due on the 30th June next on the debentures of this company will be paid by Messrs. Barclay, Bevan, and Company. The coupons must be left three clear days for examination.

Electric Lighting at the Reform Club.—The electric light at this club, where the Elphinstone-Vincent machine is working Woodhouse and Rawson's lamps, has given so much satisfaction that the committee are now extending it to the billiard room.

Faure-Sellon-Volckmar Accumulators.—Mr. Emile Bürgin, the eminent electrician of Basle, has, by an arrangement with the Electrical Power Storage Company, secured the sole agency for the supply of the Faure-Sellon-Volckmar accumulators in Switzerland.

Illustrated Catalogue.—We have received the illustrated catalogue published by H. and E. J. Dale, of 26, Ludgate Hill, containing, besides the usual descriptions of electrical appliances, some special applications of electricity to the purposes of photography.

South Africa.—The Eastern Telegraph Company notify that the Eastern and South-African Telegraph Company's cable between Zanzibar and Mozambique became interrupted on Saturday afternoon. The company's repairing ship stationed at Zanzibar proceeded at once to restore communication.

Cochin China.—A despatch from Saigon announces that the Colonial Council has passed a resolution in favour of the construction of the telegraphic cable between Saigon and Haiphong, at the same time agreeing to bear the whole cost of the undertaking, provided that Tonquin and Cochin China remained united.

The Electric Light at the Fisheries Exhibition.—A great display of electric lighting will be witnessed at the garden party advertised to take place in the grounds of the Fisheries Exhibition this evening, and the arrangements for illuminating the buildings and grounds during the remainder of the exhibition are said to be now completed.

Caen.—The Caen Exhibition, opened on 5th June, and which will remain open until the 15th September, is illuminated in the evening by incandescence lamps, the current for which is supplied by an Edison dynamo, and also by a Berjot arc lamp, worked by a Méritens dynamo. Dupuy's electric locomotive, which unrolls and rolls up cloth to be bleached, is exhibited.

An Electric Rifle.—A rifle, invented by M. Clair, of Paris, is to be exhibited at Amsterdam, the powder charge of which is ignited at the front end by a platinum wire heated to redness by an electric current being passed through it, a simple "push" taking the place of both hammer and trigger. The current is supplied by an accumulator about the size of a good sized watch, placed in the stock or carried in the pocket. Two or more charges contained in the same barrel may be fired successively by employing platinum wires of different diameters, the smallest of course getting red hot first.

The Edison Exhibit at Vienna.—This exhibit will consist of three dynamo machines, one K, one L, and one Z. The K and L dynamos will be driven by an Armington and Sims engine. The Z machine will be driven by a separate 8 horse-power engine. Specimens of all the lamps made, and in fact, specimens of the various parts of the Edison system of lighting, will be exhibited. Part of the main building will be lighted by Edison lamps, as well as the "Restaurature," in Süd-West-Hof," some 175 metres from the machines. The fitting up of the exhibit will be under the supervision of Mr. F. Jehl.

Magnets.—In a short note on the carrying power of magnets in *La Nature*, June 23, a curve is shown as constructed by M. Séquard by means of the formula $p = a \sqrt[3]{w^2}$, where p = carrying power of magnet in kilogrammes, w = the weight of magnet also in kilogrammes, and a = a coefficient, which, for good steel, varies from 18 to 23. M. Séquard constructed his curve with $a = 20$. The conclusion of the note is that with magneto machines small coils should be exclusively used, and that in dynamos the coils moving in a magnetic field should be somewhat large.

The Dynamicables.—The idea, originating in Paris, of electricians meeting together for the purpose of dining and an evening's social intercourse has borne fruit in London, and a society under the name of the Dynamicables is gathering into its folds all those convivial spirits who like to meet and wyne. Each meeting has a new president, the principal function of the president being to nominate his successor. Each member has the pleasure of paying a half-guinea subscription per annum, and also of paying for his dinner. The next meeting of this social club will be held at the Fisheries Exhibition the first Friday in July.

Electric Lighting on Board ss. "Burmah."—The ss. "Burmah," 2,000 tons, built by J. Key and Sons, Kirkcaldy, has just been completed, and is fitted up with the electric light, Higgs's self-regulating dynamo being employed, and 70 incandescent lamps of 20 candle-power and 2 "arc" lamps of 2,000 candle-power are used. The trial is said to have proved a most decided success, and satisfaction was expressed on all sides, the extreme softness and steadiness of the light being commented upon. The work has been executed by The Electric Carbon Storage and Apparatus Manufacturing Company of Scotland (Limited), of Leith.

New Electric Safety Lamp.—M. A. H. Boullenot, *aîné*, chemist, writes from Issy-sur-Seine to the *Journal des Mines* that the Davy miners' lamp ought to be discarded now that there are Edison, Swan, and Maxim incandescence lamps in the market, only there is the difficulty of either fixing permanent conductors, or of dragging them about along with the lamp. He, M. Boullenot, has solved the problem of constructing a portable, self-contained incandescence lamp, which also gives warning of the presence of firedamp. He does not give particulars because his patents are not yet secured; but why does he not enter the lamp for Mr. Ellis Lever's £500 prize?

"Proceedings of the Royal Society of Edinburgh."—The number of the *Proceedings* just issued, viz., No. 112, contains comparatively few important papers on electrical subjects. We notice the following, "The Effect of Moisture on the Electric Discharge," by A. Macfarlane, M.A., D.Sc., and D. Rintoul, M.A.; "The Heats of Combinations of the

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Metals with the Halogens," by Messrs. A. P. Laurie and C. J. Burton. This investigation is referred to in two papers, the first paper being simply preliminary, and was carried out with the "cuprous iodide cell." "On the Change in the Peltier Effect due to Variation in Temperature," by Mr. A. Campbell.

The Eastern Telegraph Company.—The Eastern Telegraph Company announce that, subject to the final audit, the accounts show, after placing £85,000 to reserve fund, a balance available for dividend sufficient to pay at the general meeting on 12th July next, the fixed dividend of 3s. per share, less income-tax, being at the rate of 6 per cent. per annum on the preference shares, and a final dividend of 2s. 6d., with a bonus of 1s. per share, both free of income-tax, on the ordinary shares, making, with previous payments on account, a total dividend of 6 per cent. on those shares for the year ended 31st March, 1883, and carrying forward a balance of about £2,790.

Time by Telegraph.—Under this heading the *Scientific American* mentions an improved method of synchronising clocks, and says: "The problem of correcting clocks throughout cities and towns by electricity has been heretofore supposed to be unattainable; by Mr. Hamblet's system, with a good clock at a central station, provided with the proper mechanism to send a single beat, not to exceed one second in duration, exactly at the beginning of each hour, and inexpensive clocks located in places within convenient reach of a local system of telegraph wires, a successful distribution of uniform time may easily and cheaply be maintained." We had thought the problem of correcting clocks by electricity was not exactly in the position herein mentioned, and that it was not only attainable, but had been and is done already by more than one system.

Photometry.—We are glad to see that Mr. Preece, F.R.S., has brought his proposed system of photometric measurement before the notice of the Royal Society. The standard of reference is a given surface illuminated to a given intensity, the light used being that of a small incandescent lamp. The amount of illumination is measured by the amount of current, the number of amperes giving the degree of illumination. The standard is a surface illuminated by a standard candle at 12·7 inches, or a French candle at a metre distance. We do not know who was the first to suggest the use of the electric current for photometrical purposes, we think the idea originated either from Mr. Preece or the late M. Schwendler. We might here say that to the best of our belief the method of ascertaining the distribution of the lines of force, as given in a note in p. 98, was first suggested by Mr. Preece.

Determining the Value of the Ohm.—By a recent Act of Congress, says the *Electrical World*, experiments will soon be in progress for determining exact values for several electrical constants. By the Act a committee of the recent electrical congress, consisting of Professor Rowland, of the Johns Hopkins University, Professor Trowbridge, of Harvard, and Professor Barker, of the University of Pennsylvania, has been authorised to undertake these experiments, and the work has been so apportioned that Professor Barker will determine the resistance of a given column of mercury. Professor Trowbridge will experiment on atmospheric electricity, and the most important feature, the determination in absolute measure of the standard of electrical resistance, the ohm, will fall to Professor Rowland, who will be assisted by Messrs. Kimball and Goodenow. The work will be done at Clifton, a suburb of Baltimore. It will begin in September, but the work of placing the necessary apparatus in position will go on during the summer.

The Future Electrical Engineer.—The electrical engineer of the future, says the *Mechanical World*, must have a sound practical training in the schools and shops, and more especially in the latter. He must be well grounded in the physical sciences and in mechanics, for he will have under his control complicated engines and machinery, and in their installation will have to be prepared for unexpected contingencies. He must be able to select the best engines and boilers for his purpose, to put them down, and design the best means for driving his machines; be prepared for breakdowns, with the best means for preventing and remedying them without calling in the advice of his brother the mechanical engineer. In hydrostatics and pneumatics, because of the analogies existing between these and electricity and magnetism. In sound, light, and heat, for a similar reason. In electricity and magnetism, in order that he may be acquainted with the basic theory of his profession, whatever it may happen to be at the moment. Besides all this, he must be a fair mathematician, and have a little more than a smattering of chemical knowledge.

Electricians in France.—On Thursday, June 21, was held at Durand's the fourth meeting of electricians of the society founded by the Comte d'Aros. It was decided (says *The Times*) by the meeting that a committee should be appointed to frame the articles of a new society for encouraging progress in electric science and corresponding with those in all countries who have made electric questions the chief object of their studies and efforts. This evening's banquet was presided over by M. Loewy, member of the institute, who had on either side of him M. de Lesseps, M. Faye, M. Robin, Admiral de la Gravière, M. Louis Figuier, and some 30 or 40 others, including 12 members of the institute, senators, deputies, journalists, and men bearing names well known in different branches of science. At the close of the dinner, between the toasts, M. de Lesseps announced a piece of news of importance. The president of the Suez Canal Company appealed to the members present to compete for a prize for the best means of lighting the canal by electricity. Without entering into details it is evident that such an innovation would very largely increase the capacity of the canal for traffic.

Electricity in a Rage.—The Philadelphia *Public Ledger* of May 26 says:—"During the thunderstorm on Monday night last, when the atmosphere was overcharged with electricity, a curious phenomenon occurred at Fourth and Arch streets. At that point the wires of the Reading Railroad Telegraph Company cross those of the Maxim Electric Light Company. In some manner unexplained, the wires of the two companies were brought in contact, resulting in the wires of both companies being completely burned through. The electricity then burned up two of the Maxim lamps, and rushing to the leading office on Fourth-street, destroyed several boxes and machines. During the same storm the wires of the Western Union and other companies being thoroughly wet, a current of electricity from the atmosphere straddled one of the wires and slid along to the switch-board in the office of the Western Union, setting it on fire and burning several instruments. Several of the wires burned completely through are in the possession of the police and fire alarm telegraph offices. For the time being several circuits were broken, but everything was soon placed in working order."

D'Or's Battery.—In answer to our request for information, a long advertisement from the *English Mechanic*, and

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an extract from the correspondence columns of that paper have been kindly forwarded. We give the extract, which is as follows: "In answer to Albert Jenkin, inquiring about D'Or's battery, I can say it is a bichromate battery. The one I have ran down in three hours. It is his No. 2 battery. Here are the directions for charging it: Dissolve in a large wash jug 1lb. of bichromate of potash in nearly three quarts of boiling water, when cool add $\frac{3}{4}$lb. of commercial sulphuric acid, just giving one stir with a stick, and again allow to cool. This done, fill the jars to within $1\frac{1}{2}$in. of the tops. It has two carbons and one zinc to each cell. The carbons are $5\frac{1}{2}$in. by $2\frac{1}{4}$in.; the zinc $5\frac{3}{8}$in. by $2\frac{1}{8}$in., and $\frac{1}{4}$in. thick. There are three cells, and, of course, connected in series. It gave a light of about 1 c.-p. The method of raising the carbons and zincs out of the liquid is by means of two strings and a curtain-ring at ends of string, which, when raised, is hitched on to a screw outside of box." We have rather a strong feeling about this and similar advertisements, suspecting their tendency to mislead, but before commenting further we should like more information as to the No. 1 light.

Thunderstorms.—On the afternoon of Monday last a terrific thunderstorm burst over Chatham, and, unfortunately, caused the death of two persons, one of whom had taken shelter in a sentry-box at the Dockyard. At Cambridge, on the same day, the church of St. Botolph was struck, and some damage done. At Sturton, a cottage was struck; and various parts of Warwickshire, Leicestershire, and North Wales were visited by thunderstorms of unusual severity. At Stalybridge the Unitarian church was struck by lightning, which, igniting some birds' nests in the gutters, set the roof on fire. Two boys, who had taken shelter by a tree in the neighbourhood of Ashton-under-Lyne, were struck, one of them fatally. A similar case occurred at Lees, near Oldham, where a man was killed inside a hut which he had entered for refuge from the storm. On the previous day, Sunday, the Black Horse, at Rampton in Cambridgeshire, was set on fire by lightning and completely destroyed. The roof of a house in Huntingdon-street, Cambridge, was fired during the storm on Monday. In the afternoon of the same day a farm at Great Eversden was struck by lightning, and nearly the whole premises, together with some of the stock, were destroyed by fire. On Tuesday a house in course of erection at Kempton was partially demolished by lightning, which also killed a child in the same locality.

Overhead Telegraph Wires.—Mr. Fawcett, replying to Mr. Stuart-Wortley, in the House of Commons, on the 21st inst., said that, after careful consideration, he had come to the conclusion that it was beyond the province of the Post Office to inquire into the condition of overhead wires not belonging to the Post Office, unless they interfered with the working of the Post Office wires.—On Monday last Sir C. Dilke being interrogated on the same subject stated he had that day received a deputation from the vestries of the metropolis in conjunction with the Under-Secretary for the Home Department. The question had also been referred by the Home Office to the metropolitan vestries for information. There could be no doubt that in the city and in portions of Westminster there was a certain number of abandoned lines. The vestry of St. Mary, Newington, stated that if any such existed in their district, they would immediately take steps for their removal. The vestry of St. Giles made a statement which showed that in the opinion of some vestries ample power to deal with the subject existed in the present state of the law. They said that overhead telegraph and telephone wires had been stretched across the streets, but in all cases where the owners of abandoned wires had been ascertained the board had adopted steps to compel the removal of them, or, where they had permitted them to remain, to compel their being subjected to proper supervision.—Mr. Stuart-Wortley asked if those vestries which disputed their interest in the soil disputed their liability for injury?—Sir C. Dilke said the liability was in the person who erected the wires. The question of liability when no owner could be found had not yet arisen.

Legal.—In the House of Lords, on June 26, the case of Christopher *v.* the United Kingdom Electric Telegraph Company was heard by the Lord Chancellor, Lord Blackburn, and Lord FitzGerald. This was an appeal from a decision of the Court of Appeal, affirming a judgment of the Queen's Bench Division. Mr. Cottrell, Mr. Spalding, and Mr. Hunter appeared for the appellant; and Mr. J. G. De Witt for the respondents. The action in which the order appealed against was made was originally brought by one Thomas Allan, deceased, against the respondents in the Queen's Bench for the recovery of the sum of £20,000 for an alleged breach of agreement. The respondents, by their pleas, pleaded that before the action was brought the agreement relied upon had been rescinded. It appeared from the appellant's case that Mr. Allan, the original plaintiff, was a gentleman of great scientific turn of mind, and devoted himself to the development of telegraphy. In 1860 he became connected with a number of gentlemen who proposed to form a joint-stock company to purchase and work his system of telegraphy, and it was agreed that he should become the electrician and chief engineer of the company at a salary of £2,000 per annum, and should receive £10,000 in cash and £15,000 in fully paid-up shares of the company, with a royalty for the use of his patents. Mr. Allan afterwards received notice that this agreement had been rescinded, and subsequently the company received £636,000 from the Government for their undertaking, whereupon Mr. Allan brought the present action to enforce the agreement. The Queen's Bench decided against his claim, and their decision was supported by the Court of Appeal. Mr. Allan having died, the present appeal was brought by his executor. Their lordships now affirmed the decision of the Court below, and dismissed the appeal.

Earthquake in the West of England.—On Monday last a shock of earthquake was felt in many parts of Cornwall, and particularly on the north coast, and occasioned considerable alarm throughout the county. At Bude the shock is described as being of an extraordinary character, and not only was it felt there but all along the coast. The shock was quick and sharp, but sufficient in force to shake the houses to their foundations, and to cause a sensible oscillation of furniture in the rooms. In several instances articles of glass and crockery were thrown down and broken. At Stoke Climsland two shocks were experienced, the first about half-past one and the second half an hour later. The rectory house, a large and substantial building, shook very perceptibly, and some members of the rector's family who were in the church at the time state that the church also was shaken, and that chains hanging from the roof, from which in winter coronas are suspended, oscillated for some minutes. Some scaffolding, erected round the church to enable painting operations to be carried on, also shook as if it would fall. At Launceston and neighbourhood there were two distinct shocks. There was a low rumbling noise heard as of a heavy waggon passing, accompanied by considerable vibration, and the windows of the houses and shops were shaken for several seconds. A second shock was not so severe as the first; but there was no mistaking it. Similar reports have been received from Horrabridge, Lawhitton, Calstock,

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Southpetherwin, and other places in the county. Later accounts show that the earthquake in the West of England was more general than at first supposed. Not only was it felt in North Devon and Central Cornwall, but it appears to have extended above the South Devon and Cornwall coasts. As far west as St. Blaze a glass was shaken out of a rack and broken. At Plymouth the vibrations were so slight as not to attract general notice, but it is now evident that they were felt in the environs, but in the town were mistaken for the passage of heavy vehicles.

Professor Tyndall and the Board of Trade.—In reference to Professor Tyndall's resignation of his position as Scientific Adviser to the Board of Trade, Lord Sudely stated in the House of Lords, on the 21st inst., that it was not the fact that the Corporation of Trinity House or the Board of Trade had acted towards him in a high-handed manner. He resigned because he did not approve of the constitution of the Committee of Inquiry, and because he did not think that with Mr. Wigham and Sir James Douglas on it as patentees there would be a fair trial. He also made certain charges against the Board of Trade and Trinity House, saying that for many years past the board had not given proper support to the gas system, and that in 1879 the system was actually brought to the verge of destruction. A great deal of what occurred had taken place before the present Government came into office. Since then everything had been done that could be done in the matter. The Corporation of Trinity House, the Commissioners of Northern Lights, and the Board of Trade agreed that the charges made by Professor Tyndall were quite unfounded. He had stated his grounds for thinking that the gas light was decidedly the best, and said that the experiment had proved it; but the fact was that there had been no experiments whatever. The position of the Board of Trade in the matter was that of a mediator between the lighthouse authorities, who differed on the question—certainly as regarded gas and oil—the Commissioners of the Irish Lights having expressed themselves as being decidedly in favour of the former, whilst the Commissioners of Northern Lights and the Trinity Board had taken an opposite view. The Board of Trade were only desirous that the question should be fairly tested; and after Mr. Chamberlain had made inquiries personally in Ireland, and consulted the authorities on the subject, it was resolved that there should be a more extended inquiry than could be had by the original committee, and that a new committee should be appointed. The preliminary trials were, therefore, given up. Professor Tyndall expressed himself very strongly with respect to Mr. Wigham and Sir James Douglas as members of the committee, on the ground that, as he maintained, both were prejudiced—the one as to gas and the other as to oil. The former was a manufacturer, but the latter was not, and incurred all the expenses of his patent without any contribution from the Board of Trade. Soon after this, the President of the Board of Trade had an interview with Professor Tyndall, and, having gone into the question fully with him, came to the conclusion that it would be far better to have some other authority thoroughly impartial to assist the board as their scientific adviser besides Professor Tyndall, and to appoint Mr. Vernon Harcourt. Professor Tyndall was, undoubtedly, a gentleman who stood very high in the scientific world, and was well known for his independence and integrity, but it was also well known that he was a gentleman who was apt to take very strong views, and, having taken those views, he was the most difficult man in the world to get to alter them. He (Lord Sudeley) was sorry to have to say, but he felt bound in justice to the Board of Trade to say it, that in his correspondence with the board Professor Tyndall had shown throughout a disposition to impute motives to other people, and pecuniary interests to different gentlemen of the committee, which the Board of Trade thought he certainly ought not to have done.

Overhead Wires. — Deputation to the Local Government Board.—On Monday afternoon a deputation from the vestries of Marylebone, St. George's, Hanover-square, and St. James's, Westminster, accompanied by representatives from most of the other metropolitan vestries and boards, including the City Commissioners of Sewers, waited upon Sir C. Dilke, M.P., at the offices of the Local Government Board, with the object of seeing what steps could be taken to put a stop to the dangerous practice of fixing telephone and telegraph wires over the streets of the metropolis. After pointing out the danger which was created by the ever-increasing number of wires that were being placed over the streets, Sir Arthur Hobhouse said some persons seemed to think that the vestries could interfere in the matter and prevent the erection of them, and were even liable for damages should any accidents occur. The Government were, however, the proper authority to deal with a new practice of this nature, there being no adequate law, so far as he was aware, to enable the vestries to meet effectually the exigencies of the case.—Sir C. Dilke, in reply, said that the general view the Government took upon the matter was that the owners of the wires had no greater rights of interfering with the public streets and placing wires across them than any member of the public. They were in the position of any ordinary individual. The Government did not think that such persons could, either with or without the assent of the local authorities, interfere with public highways in such a way as to cause obstruction to the public, even though such obstruction was limited to the time during the execution of those works. The Government were not prepared to say that in all cases it would be unlawful to carry wires across the streets where the consent of the owners of the buildings had been obtained. It would be a question of fact in each case whether the wires so suspended were the source of such probable danger as to constitute a nuisance, and that would depend upon a number of considerations, such as the width of the streets, the number of the wires, and the distance they were apart. No doubt a great danger did exist owing to these overhead wires, and the question was whether in the face of so great a risk the vestries had not the power to interfere. He agreed if they had not such powers they ought to be obtained, and that it ought to be made quite clear whether they had such powers or not. It was mentioned by one of the speakers that there were miles of overhead wires in the metropolis for which no owners could be found, and that was a fact of importance, as the wires would be allowed to get out of repair through neglect, and accidents would ultimately follow. He thought it very probable, if the case were tried, that it would be found that the vestries had sufficient powers to prevent the erection of overhead wires; and it was desirable that they should be clear on that point before any legislation was attempted. If it were found that the local authorities had no power to control the erection of these wires, then he was of opinion that legislation on the subject should take place, the proper body to initiate which ought to be the Metropolitan Board of Works. He could not, however, but think that the present law would be found sufficient to deal with the question, and he would be sorry to initiate general legislation upon it unless it were made quite clear such was not the case. The deputation then withdrew.

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CURRENT ENERGY.—V.

BY OLIVER HEAVISIDE.

(CONTINUED FROM PAGE 105.)

Given a magnet placed near a closed circuit with no current in it. There is *no* mutual force when they are at rest, and it is not immediately evident that there should be any when the magnet or the conductor is moved. But, following Helmholtz, if we start with a current in the conductor, kept up by a constant E.M.F., we can go further. For now there is force between them, exactly determinate when the data of shape. &c., and strength of current and of magnetisation, are given. Let the positions be such that there is a repulsion of whole amount F, so that a pressure of this amount must be applied to prevent the magnet and conductor separating further. Now push the magnet towards the current through the space dx. The amount of work externally spent against the force F during the operation is Fdx, and by the principle of the conservation of energy an equal amount of energy is put into the system, and must be accounted for somewhere. But where to look for it conservation will not tell us, and more facts are needed to assist us to a definite conclusion. As a matter of fact, the work spent is accounted for finally as heat in the conductor. How it gets there is a mystery. The current in the conductor is increased by the motion of the magnet, the rate of transfer of energy from the battery is also increased, the generation of heat which is inseparable from the existence of conduction currents is likewise increased, and this additional generation of heat is the equivalent of the additional energy leaving the battery *and* of the external work spent against the electro-magnetic forces. This is sufficiently complex, but the reality is even more so, for the above supposes that the motion is such that the induced current is not changing, that is, that the actual increased current remains steady. We see, however, preliminarily, that the energy put into the system externally by moving the magnet must exist in at least one intermediate form before it becomes heat in the wire, for it has to be transmitted across the intermediate space and the heat is not generated at the place of external work, as when a button is rubbed upon the coat sleeve. Now, this intermediate energy must also be taken into account when the induced current is not steady, for then there will be no longer equivalence between the rate of generation of heat and the rate of supplying energy from the battery and from the external source, the difference going to the intermediate form.

But to develop this matter it becomes necessary to take a general view of the connection of Ohm's law with Joule's law, and the principle of conservation as concerned in the transfer of energy from a battery in *steady* action. As regards Ohm's law, if there is little to be said that has not been said over and over again, it is certain that a good deal of nonsense has been written about it. Perhaps no scientific law has had so much unscientific discussion, a result to be attributed in the main to its remarkable practical importance bringing it down from the professors to the multitude, which must always contain amongst the great mass who are willing to learn, and are too modest to imagine, if they cannot understand a thing, that the professors are all wrong, a certain number of self-confident paradoxers, whose peculiar conceit is that their views are necessarily right. Self-confidence is, no doubt, an excellent thing in its way, but when coupled with ignorance of the fundamental truths of dynamics (which they should know is an *exact* science), leads to extraordinary jumbles sometimes. Did they only deceive themselves in their delusions little harm would be done, but when they take to writing books for students, then, Lord save us! a whole body of blind followers is precipitated into the ditch of mental confusion, from which extrication is so difficult, and whose mud sticks for so long.

In any conductive metallic circuit in which a steady current is flowing, if there be any connection at all between the current C and the whole electromotive force E in the circuit, we may write $E = f(C)$, some function of the current, and, it may be, of other quantities. Or we may say $E = RC$, where R is the ratio of the E.M.F. to the current, and R may be a function of the current and of other quantities. Now, according to Ohm's law, this ratio is constant for a particular circuit, that is, is independent of the current. Increase the E.M.F. in any proportion, and the current will be increased in the same proportion. There is a reservation to be made, viz., that the temperature must be kept constant, otherwise the ratio will slightly change. Also another of lesser immediate importance that the long-continued passage of currents may slightly alter the ratio, a result probably due to some structural alteration produced in the conductor. And minute changes may be due to other causes, but practically the ratio is a constant.

What is true for a complete circuit is also true for any portion thereof, the ratio of the E.M.F. in that portion to the current is constant, and this naturally leads us to the most general way of stating Ohm's law, which is to take the unit volume (cube) of a conductor, with two opposite faces perpendicular to the current, and apply the law to it. Let e be the E.M.F. between the faces mentioned, and c the current crossing them and every intermediate section of the cube, then $e = rc$, where r is constant for the *material*. Here e is the E.M.F. per unit of length (or E.M.F. at a point) c the current per unit area (the current density, or current at a point), and r the specific resistance per unit volume.

Another useful form is $c = ke$, where k, the constant ratio of the current to the E.M.F., is the specific conductivity, the reciprocal of r.

Corresponding to $c = ke$ in a conductor we have $D = Ke$ in a dielectric, where D is the displacement produced by the E.M.F. e, D referring to unit surface and e to unit length as before, and K being a constant for the material.

Again, we have in induced magnetisation the analogous law $B = \mu H$, where μ is the ratio of the magnetic induction B to the magnetic force H. And similarly $I = \kappa H$, where I is the magnetisation produced by H, and κ their ratio.

But the constancy of K in any dielectric is by no means well assured, whilst in solid dielectrics there is the complication introduced by the phenomenon of "absorption," making the value of K appear to vary according to the time the E.M.F. has been acting upon the dielectric, and the displacement already produced, a phenomenon analogous to the effects of imperfect elasticity in bodies under stress.

And κ and μ in magnetisation are only constants (approximately) for weak magnetic forces; their values fall very rapidly when the force is greatly increased, a limiting maximum magnetisation being reached.

On the other hand, Ohm's law is remarkable in that the ratio r remains constant from the lowest to the highest E.M.F.'s, a constancy which could not be predicted or expected *à priori* with any certainty in our ignorance of the nature of what is really going on in a body carrying a current.

The constancy of r implies that the existence of one current in a wire does not in any way alter the wire so as to interfere with its capacity for bearing another current if the required additional E.M.F. act, which is very different from the superposition of magnetisations, where the effect of additional magnetic force depends upon the already existing state of magnetisation. An immediate consequence is that any number of E.M.F.'s may be superimposed at any point of a conductor, the resulting current being the algebraical sum of the currents the E.M.F.'s would separately produce if they act all in the same line; and when their directions are not all the same, the resultant current and resultant E.M.F. have the same direction, and have the same ratio of magnitude r as any of the component E.M.F.'s and currents, of which they are the vector sums.

With the application of Ohm's law to practical circuits and its developments we have no concern here, but a few remarks as to some misunderstandings may not be out of place.

The constant R in $E = RC$ is called the resistance of the circuit (or portion thereof, as the case may be). Notice that it is "called" so. Now, students are sometimes led, or rather misled, by the name and by certain ideas they may possess as to frictional resistance to imbibe the idea that R is really analogous to the frictional resistance to the flow of water through a pipe, when the current of water is compared to the electric current. To credit them with supposing it to be not merely analogous to, but actually frictional resistance,

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would be to place them in the category of "men of science who are not natural philosophers," described by Maxwell, who seized on the word Fluid as something intelligible, and forthwith endowed electricity along with fluidity, with mass, inertia, &c. But still the student, if he avoids the error of the knowing men who loved not Sophia, may be temporarily under the delusion that R is analogous to frictional resistance. That it is not so he soon finds out, as a general rule, when he gets a little further into the matter. Should he, however, be unfortunate enough to keep the idea long enough to allow it to crystallise, it requires later a great effort to get rid of it. Then, when the time comes, he, after profound cogitation, rises up and repudiates the idea, and perhaps rushes into print with his discovery, reminding one of the example of the atheist (who was a thief) who made the bold declaration that so startled his hearers, that "todestools *ain't* what the todes sit down on, but is just *called* so." Exactly, R is just called so.

The real analogue to the frictional resistance of water flowing through a pipe is not R, but RC in the electrical case. Thus, if we set water in a pipe in motion, driving it by means of a constant difference of pressure between its ends, the velocity will increase until the motive force is just balanced by the frictional resistance. Now, let the frictional resistance be exactly proportional to the velocity, as it is said to be approximately for low velocities in thin pipes. Then, if C' be the current, $R'C'$, where R' is some constant multiplier, will be the frictional resistance, and C' will increase until $R'C'=E'$, which gives the steady current corresponding to the motive force E', after which there will be no further acceleration of velocity.

Now, representing the difference of pressure by the E.M.F. in the wire, and the current of water by the electric current, the analogue of frictional resistance in the pipe is RC, and the constancy of R (which is analogous to the coefficient of friction) implies that the resistance is proportional to the current.

Again, if ideas are correct, it is of secondary importance what language is used to express them, but it certainly would appear that, when people say that a certain E.M.F. is required to enable the current to *overcome* the resistance of a wire, it is the idea that is wrong. For there is really no question of overcoming, though there is of coming over. To every E.M.F. corresponds its definite current, neither more nor less. To give a parallel case in mechanics. A body resting on a level surface is set sliding under the application of a constant force; what velocity it will assume depends upon the friction when in motion, since there is no lifting work done. Assuming, for the sake of argument, that it is proportional to the velocity v, say Rv, where R is the coefficient of friction, and that F is the applied force, $Rv = F$ determines the steady velocity similarly to the case above. The final velocity and the applied force are in a constant ratio. Here there is no question of overcoming, for it is the motion that brings the resistance.

But if the body be at rest, there will be a definite force required to set it moving at all, depending upon the statical friction. There is really a resistance to be overcome before the body will move. But this has no analogue in conduction currents in metals; the least E.M.F. will set up its corresponding current, down to the smallest measurable, and there is no initial resistance to be overcome. In gases, however, there appears to be something of the kind, and naturally we find it expressible as E and not as R. Thus Mr. Varley found that 323 cells were required to start the current in a certain tube, although when set up the current was that due to the excess of the E.M.F. over 304 cells, following Ohm's law thereafter. The initial $E = 323$ Daniells is analogous to the statical friction. For the rest, the analogy is not a good one for our purpose.

Ohm's classical memoir of 1827, "The Galvanised Kettle Mathematically Tinkered," of which a translation is to be found in Taylor's "Scientific Memoirs," contains a good deal more than $E = RC$. Therein will be found the laws of distribution of potential in different parts of a circuit, with the well-known zig-zag lines showing its changes in passing through a battery of many cells. Also, if I remember rightly, the method of joining up cells to get the maximum current in a given external resistance, and the corresponding law for the size of wire of a galvanometer. There is, besides, an analytical investigation relating to the propagation of electricity in a wire, wherein, proceeding upon an entirely erroneous assumption regarding the power of a wire for storing up electricity in its bulk, like heat, following in fact Fourier's investigation of the conduction of heat, he was led to the true equations for the propagation of potential in a long wire, with electro-magnetic induction neglected, afterwards legitimately established by Sir W. Thomson, and he gave the solution in the case of a constant E.M.F. put on at the beginning of a wire, the end being to earth. Why he should have come to the right result by a wrong method was simply that, whether electricity is stored up in the substance of a wire, or goes to the surface and stays there, the equations are of exactly the same form.

(TO BE CONTINUED.)

ON THE RESISTANCE OF THE ELECTRIC ARC.

By O. FRÖLICH, from the *Electrotechnische Zeitschrift*, April, 1883.

Opinions as to the nature of the resistance in an electric arc are very various, even at the present day. Perhaps the first work upon the subject is that by Edlund (*vide Poggendorf's Annalen*, v. 131, p. 586). In this the arc is compared to a galvanic cell, and preserving the analogy, the induced counter E.M.F. and the true resistance of the arc are determined experimentally in a number of cases.

Edlund's work has not been in requisition of late, probably because he worked only with batteries and very moderate lights, and hence his results are not directly applicable to the intense lights of the present time. On the other hand, there is the question whether or not the arc possesses a counter E.M.F., and attempts have been made to settle it experimentally. This is difficult, and it is indeed doubtful whether it is even possible to arrive at an experimental proof. Among the many attempts of this kind I know of none by which the existence of a counter E.M.F. is proved with anything like certainty.

In many scientific and technical works we meet with the rule that the E.M.F. of the arc, measured between the two carbons, has a fairly constant value, about 50 volts (see, for instance, Richter, *E. Z.*, 1883, p. 29). I am convinced that many constructors apply this rule, though, as far as my knowledge extends, it has not been submitted to a more exact examination.

That the rule cannot be strictly true is proved by the consideration that according to it the electrical elements of the arc would have to be independent of the length. This is contrary to the fact that the resistance of the arc, when the current is maintained constant, increases with the length of arc. This fact lies at the root of all constructions of electric lamps, and is unquestionable.

The resistance of the arc is the relation between the E.M.F. between the carbons and the current. We will call it the apparent resistance, because we are as yet uncertain that an induced counter E.M.F. is not produced, and the resistance in this case will not be an element of the same physical character as in the case of an ordinary conductor.

The apparent resistance of the arc depends upon the current and the length of arc. For the nature of this dependence we require observations in which these quantities have the most different values possible, and these the trials of Messrs. Siemens and Halske, given in Table I., afford us, from which we will endeavour to educe the function desired.

To detect directly the law for the apparent resistance is hard, because it depends upon two independent variables. It is better to see if in the connection between the E.M.F. and one of the variables the other does not disappear, or, perhaps, appears only to exert an unimportant influence.

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Table I.

Date.	Machine.	(*a*)	(*b*)	(*c*)	(*d*)	(*e*)	(*f*)
16th October, 1882.	D_7	30,4	4,3	45,9	46,9	1,52	1,54
		27,4	2,0	42,7	42,8	1,57	1,56
		36,2	2,8	35,4	44,2	0,99	1,22
		40,4	2,0	39,5	42,8	0,99	1,06
18th and 20th October, '80.	D_8	36,0	5,5	45,7	49,1	1 28	1,36
		39,4	6,5	53,0	50,9	1,35	1,29
		41,8	4,6	46,3	47,5	1,12	1,14
		40,8	7,8	51,1	53,2	1,26	1,30
21st October, 1880.	2 D_8 one behind the other.	30,4	7,0	53,8	51,8	1,79	1,70
		34,6	14,0	61,9	64,3	1,80	1,86
		42,7	15,0	62,3	66,1	1,47	1,55
		40,8	15,0	68,3	66,1	1,68	1,62
22nd October, 1880.	2 D_8 parallel.	60.7	14.0	66,1	64,3	1,10	1,06
		58,0	9,8	54,6	56,7	0,95	0,98
29th June, '81.	D_5	11,6	2,0	46,3	42,8	4,01	3,69
		9,01	3,5	54,6	45,5	5,97	5,65
		9,79	4,0	51,6	46,4	5,29	4,74
		8,39	2,0	50,1	42,8	6,01	5,10
		7,67	2,0	47,1	42,8	6,18	5,58
		6,92	2,0	50,1	42,8	7,28	6,18
		4,74	1,5	47,1	41,9	9,99	8,84
		4,74	1,5	42,6	41,9	9,04	8,84
		4,00	1,0	36,6	41,0	9,23	10,3
17th February, 1881.	D_6 one behind the other.	22,0	5,0	51,6	48.0	2,35	2,18
		21,1	6,0	54,9	49,8	2,54	2,36
		27,6	7,0	58,2	51,6	2,16	1,87
23rd to 27th February, '81.	D_7	19,1	5,0	55,7	48,0	2,41	2,51
		19,1	5,0	46,6	48,0	2,46	2,51
		20,8	7,0	47,4	51,6	2,30	2,48
		19,4	4.5	44,8	47,1	2,32	2,43
		21,6	5.0	45,6	48.0	2,12	2,22
		21,6	6.0	50,1	49,8	2,33	2,31
		19,4	4,8	47,2	47,6	2,44	2.45
		20,3	5,0	46,3	48,0	2,29	2,36
30th March, 1881.	D_6	39,8	4.5	44,0	47.1	1.11	1,18
		46,6	5.0	44.0	48,0	0,95	1.03
		35,9	3.9	40,6	46,0	1,14	1,28
		39,8	4,5	42,2	47,1	1,06	1,18
		45,8	4,9	45,6	47,8	1,00	1,04
20th July, '81.	D_0	114	8	53.8	53.4	0,48	0,47
		120	10	53,8	57,0	0,45	0,48
		106	12	59.0	60,6	0,56	0,57
		112	10	60.5	57.0	0.55	0,51
		106	12	58.2	60,6	0,55	0,57
		89,6	16	63,5	67,8	0,55	0,76
25th July, '81.	D_8	8,76	3,5	50,1	45,3	5,73	5,17
		8,76	3,3	49,3	44,9	5,64	5,13

Table I.—(*a*) C, current in amperes. (*b*) L, length of arc in millimetres. (*c*) E, E.M.F. between the carbons in volts (observed). (*d*) E, in volts (calculated). (*e*) R, apparent resistance of arc in ohms. (*f*) R, in ohms (calculated).

Table II.

Length of Arc in millimetres.	E.M.F. in Volts.	Resistance in ohms. Current in amperes = 1	5	10	15	20	30	40
0	39,0	39,0	7,80	3,90	2,60	1,95	1,30	0,98
1	40,8	40,8	8.16	4.08	2,72	2.04	1,36	1,02
2	42.6	42,6	8.52	4.26	2,84	2.13	1,42	1,07
3	44.4	44,4	8,89	4,44	2,96	2.22	1.48	1,11
4	46,2	46,2	9.24	4.62	3,08	2.31	1.54	1,16
5	48,0	48,0	9,60	4,80	3.20	2.40	1.60	1,20
6	49.8	49.8	9,96	4.98	3,32	2.49	1,66	1,25
7	51,6	51,6	10,3	5.16	3,44	2,58	1,72	1.29
8	53,4	53,4	10,7	5,34	3.56	2,67	1,78	1,34
9	55,2	55,2	11,0	5.52	3.68	2.76	1,84	1,38
10	57,0	57,0	11,4	5,70	3,80	2,85	1,90	1,43
11	58,8	58,8	11,8	5,88	3,92	2,94	1,96	1,47
12	60,6	60,6	12,1	6.06	4,04	3,03	2,02	1,51
13	62.4	62,4	12.5	6.24	4,16	3,12	2.08	1,56
14	64,2	64,2	12,8	6.42	4,28	3.21	2,14	1,61
15	66.0	66,0	13,2	6,60	4.40	3,30	2.20	1,65
16	67,8	67,8	13,6	6.78	4,52	3,39	2,26	1,70
17	69,6	69,6	13,9	6.95	4.64	3.48	2.32	1.74
18	71.4	71.4	14,3	7,14	4,76	3,57	2.38	1,79
19	73,2	73.2	14,6	7.32	4.88	3.66	2.44	1,83
20	75,0	75,0	15,0	7,50	5,00	3,75	2.50	1,88

Length of Arc in millimetres.	E.M.F. in Volts.	Resistance in ohms. Current in amperes = 50	60	70	80	90	100	-
0	39,0	0,78	0,65	0,56	0,49	0.43	0,39	–
1	40,8	0,81	0,68	0,58	0,51	0,15	0.41	–
2	42,6	0,85	0,71	0.61	0,53	0,47	0,43	–
3	44.4	0,89	0,74	0,63	0,56	0.49	0.44	–
4	46,2	0,92	0.77	0,66	0.58	0,51	0,46	–
5	48,0	0,96	0.80	0,69	0,60	0,53	0.48	–
6	49,8	1,00	0,83	0.71	0.62	0.55	0.50	–
7	51,6	1,03	0.86	0,74	0,65	0 57	0.52	–
8	53,4	1,07	0.89	0,76	0,67	0.59	0.53	–
9	55,2	1,10	0,92	0,79	0,69	0.61	0.55	–
10	57,0	1,14	0.95	0,81	0.71	0,63	0.57	–
11	58,8	1,18	0.98	0,84	0.74	0,65	0.59	–
12	60,6	1,21	1.01	0,87	0.76	0,67	0.61	–
13	62,4	1,25	1,04	0,89	0.78	0,69	0,62	–
14	64,2	1,28	1,07	0,92	0,80	0.71	0,64	–
15	66,0	1,32	1,10	0,94	0,83	0.73	0.66	–
16	67,8	1,36	1,13	0,97	0.85	0.75	0.68	–
17	69,6	1,39	1,16	0,99	0,87	0,77	0.70	–
18	71,4	1,43	1,19	1,02	0,89	0,79	0,71	–
19	73,2	1,46	1,22	1,05	0,92	0,81	0,73	–
20	75,0	1,50	1,25	1,07	0,94	0,83	0,75	–

Let the observations be so plotted that abscissæ represent lengths of arc and ordinates E.M.F. Then we arrive at the figure (see page 152), which is a zig-zag line. The cause of the irregularities of this line is to be looked for chiefly in the fact of the observations having been taken at different times by different observers, and with different instruments, but partly in the E.M.F. not being merely a function of the arc-length, but depending in part on the current, as does the apparent resistance.

Even if such be the case, at all events the observations show that with a constant length of arc the E.M.F. is greater with a small current than with a large one. This corresponds with the case of a galvanic cell, but I do not wish to consider this point as proved before it has been made the subject of more exact experiments. We can only conclude with certainty from the above curve that the E.M.F. increases with the length of arc, and, indeed, that the ratio of increase is fairly uniform, being represented by the straight line T T.

Thus, if E is the E.M.F., L the length of arc, and *a* and *b* co-efficients, we have

(1) . . . . $E = a + b\,L$,

or, numerically, when E is measured in volts and L in millimeters,

$$E = 39 + 1{\cdot}8\,L.$$

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The apparent resistance R of the arc is obtained directly from the E.M.F. and the current C, thus :—

$$(2) \quad . \quad . \quad . \quad . \quad R = \frac{E}{C} = \frac{a}{c} + b\,\frac{L}{C},$$

or, numerically,

$$R = \frac{39}{C} + 1{\cdot}8\,\frac{L}{C}.$$

To show the agreement of these formulæ with the results of the trials of Siemens and Halske, the calculated values of E.M.F. and resistance have been registered in the table already given.

By means of these formulæ Table II. has been calculated, which will be found to be sufficiently accurate for practical technical purposes.

The question now arises whether from these formulæ anything can be gathered as to the preference to be given to one of the two views of the nature of the arc, the polarisation view, and the passage-resistance view. Taking first the polarisation view,

Let E' be the polarisation, or counter E.M.F.
k the co-efficient of specific conduction.
Q the cross section of the arc.
E the E.M.F. between the carbons.
R the apparent resistance.

For the meanings attaching to the symbols a and b we see that when $c = 1$, or when the unit of cross section is taken to be that traversed by a unit of current, a is the value of the counter E.M.F. on the one hypothesis, and the resistance between the arc and carbons for a unit cross section of arc on the other; b is, on either supposition, the reciprocal of the co-efficient of specific conduction in the arc.

We see, moreover, that the results of experiment are in keeping with either hypothesis, or, indeed, with a combination of the two.

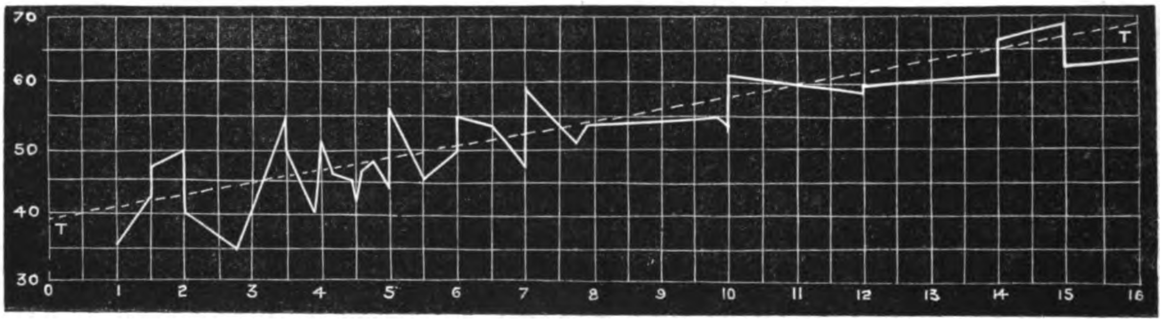
For the polarisation view we have the difference in the appearances of the carbons, and the fact that a minimum E.M.F. is required to form an arc at all.

Against this view, and for the passage-resistance view, may be urged the high value of the counter E.M.F., which is some ten times greater than all known cases of polarisation.

For the value P of the power consumed in the arc, we have $P = E\,C = (a + b\,L)\,C$. . . . . (3)

It is therefore proportional to the current, and is converted into radiant heat and light for the most part; but it is partly employed in the mechanical breaking up of the carbon particles. In these operations the power derived from the combustion assists, which also generates light and heat.

When we think that what is called the intensity or strength of the light of an arc only means the light radiation in a



Then

$$\left.\begin{aligned} E &= E' + \frac{1}{k}\cdot\frac{L}{Q}\,C \\ R &= \frac{E'}{C} + \frac{1}{k}\,\frac{L}{Q} \end{aligned}\right\} \quad . \quad . \quad . \quad . \quad (a)$$

Next suppose there is no polarisation, but at the passages between the arc and the carbons a resistance whose specific value is $r_{,}$, and whose total value, therefore, is $\frac{r_{,}}{Q}$. Then,

$$\left.\begin{aligned} E &= \frac{r_{,}}{Q}\,C + \frac{1}{k}\,\frac{L}{Q}\,C. \\ R &= \frac{r_{,}}{Q} + \frac{1}{k}\,\frac{L}{Q} \end{aligned}\right\} \quad . \quad . \quad . \quad . \quad (b)$$

Now, if we compare the formulæ a and b with the former formulæ obtained by experiments, 1 and 2, we see that a and b are both brought into congruity with 1 and 2 by the same supposition, viz., that the section of the arc Q is proportional to the current C. When we make this supposition—and it is known that the cross section does increase with the current—and write $Q = c\,C$, we get

$$\text{from } a \quad . \quad . \quad . \quad \left\{\begin{aligned} E &= E' + \frac{1}{k\,c}\,L \\ R &= \frac{E'}{C} + \frac{1}{k\,c}\,\frac{L}{C}. \end{aligned}\right.$$

$$\text{from } b \quad . \quad . \quad . \quad \left\{\begin{aligned} E &= \frac{r_{,}}{c} + \frac{1}{k\,c}\,L \\ R &= \frac{r_{,}}{c\,C} + \frac{1}{k\,c}\,\frac{L}{C} \end{aligned}\right.$$

all in congruity with formulæ 1 and 2,

horizontal direction, it is clear that this intensity is only a very imperfect expression of the power resident in the electric current. However this may be, the view so generally maintained of late, that the intensity of the light is proportional to the current, receives only support from the formula (3).

THE FIRST TELEPHONE.*

BY PROFESSOR SILVANUS P. THOMPSON.

On the 12th of May, 1862, there was met together in a fine old hall in the City of Frankfort-on-the-Main a crowded audience, eager to see and hear the latest scientific invention expounded by its inventor. The occasion was the meeting of the Free German Institute (Freies Deutsches Hochstift), a sort of literary and philosophical society, which has since domiciled itself in the historical old house where Goethe was born. The invention which attracted so notable a crowd was the telephone. The inventor was Philipp Reis, a teacher of natural sciences in Garnier's Institute, a flourishing boys' school at Friedrichsdorf, near Homburg.

On one occasion previously had the telephone been publicly exhibited; namely, at a meeting of the Physical Society of Frankfort, on the 22nd of October in the preceding year.

In the *Journal* of the Frankfort Society (Jahresbericht des Physikalischen Vereins zu Frankfurt am Main) for 1860-61, p. 57, may be found the memoir of Philipp Reis on the subject, under the title "On Telephony by the Galvanic Current." In this memoir, which shows a marvellous precision and a grasp of the subject that excites admiration and wonder, the author says :—"I have now succeeded in constructing an apparatus by means of which I am in a position to reproduce the tones of divers instruments, and even to a certain degree the human voice." The inventor

* [Reprinted from the *Proceedings of the Bristol Naturalists' Society.*]

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further says:—"Since the length of the conducting wire may be extended for this purpose just as far as in direct telegraphy, I give to my instrument the name 'Telephone.'" Toward the end of the memoir it is stated that until now it had not been possible to reproduce the tones of human speech with a distinctness sufficient to satisfy everybody; adding:—"The consonants are for the most part tolerably distinctly reproduced, but the vowels not yet to an equal degree." The author of the memoir in which these statements occur had been led to his invention by a remarkably suggestive line of thought. He had wanted an instrument

FIG. 1.

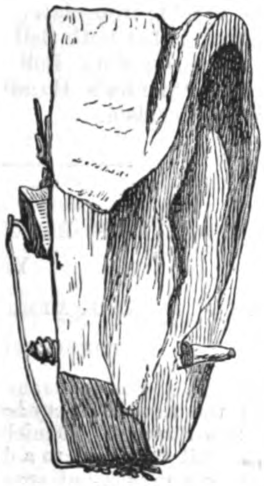
FIG. 2.

to transmit electrically everything and anything that a human ear could hear. Accordingly he took the human ear itself as a model. "How," he argues, "could a single instrument reproduce at once the total actions of all the organs operated in human speech? This was ever the cardinal question. At last I came by accident to put this question another way:—How does *our ear* perceive the total (or resultant) vibrations of all the simultaneously-operant organs of speech?" He then goes on to describe the action of the auditory ossicles when the ear is made the recipient of sound; pointing out how they execute movements and exert forces

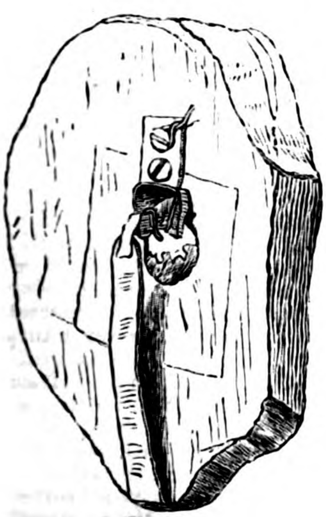
FIG. 3.

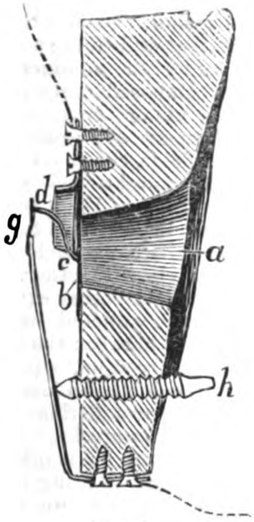

FIG. 4.

upon one another in proportion to the condensations occurring in the sound-conducting medium and to the amplitudes of vibration of the tympanum. Having stated this law of proportion between the cause and its effect, he goes on to speak of the graphic method of representing varying forces, such as those of sound-waves, by curves, and emphatically lays down that the ear is absolutely incapable of perceiving anything more than can be expressed by such a curve. After giving samples of undulatory curves corresponding to musical and to discordant sounds, he makes the following significant remark:—"So soon, therefore, as it is possible at any place and in any manner to set up vibrations whose curves are like those of any given tone or combination of tones, we shall then receive the same impression which the tone or combination of tones would have produced upon us. Taking my stand upon the preceding principles, I have succeeded in constructing an apparatus," &c. He concludes his paper by saying that the newly-invented phonautograph of Duhamel may, perhaps, afford evidence as to the correctness of the views which he has asserted respecting the correspondence between sounds and their curves.

The actual apparatus figured in this memoir, and exhibited to the Frankfort Society in October, 1861, is now in my possession; and I have also temporarily entrusted to me a still earlier experimental telephone, made by Philipp Reis, in the form of a model of the human ear.* This interesting instrument is depicted in its actual condition and size in Figs. 1, 2, and 3, and in section in Fig. 4.

It is carved in oak-wood. Of the tympanic membrane only small fragments now exist. Against the centre of the tympanum rested the lower end of a little curved lever of platinum wire, which represented the "hammer" bone of the human ear. This curved lever was attached to the membrane by a minute drop of sealing-wax, so that it moved in correspondence with every movement of the tympanum. It was pivoted near its centre by being soldered to a short cross-wire serving as an axis. The upper end of the curved lever rested in loose contact against the upper end of a vertical

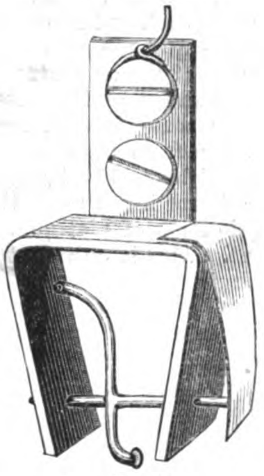
FIG. 5.

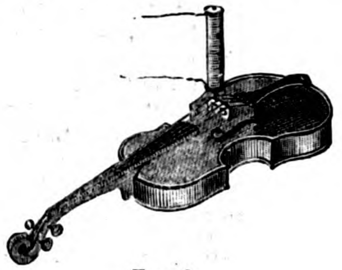
FIG. 6.

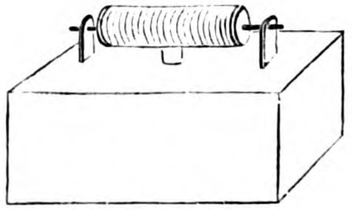
FIG. 7.

spring, about 1in. long, bearing at its summit a slender and resilient strip of platinum foil (see Fig. 4). An adjusting screw served to regulate the degree of contact between the vertical spring and the curved lever. Conducting wires, by means of which the current of electricity entered and left the apparatus, were affixed to screws in connection respectively with the support of the pivoted lever and with the vertical spring. A springy strip of platinum pressed against the end of the pivot of the lever (as shown enlarged in Fig. 5) to ensure good electrical contact.

If now any words, or sounds of any kind, were uttered in front of the "ear," the membrane was thereby set into vibrations, as in the human ear. The little curved lever took up these motions precisely as does the "hammer" bone of the human ear; and, like the "hammer" bone, transferred them to that with which it was in contact. The result was that the contact between the upper end of the lever and the spring was caused to vary. With every rarefaction of the air the membrane moved forward, and the upper end of the little lever moved backward, and pressed more firmly than before against the spring, making better contact, and allowing a stronger current to flow. At every condensation of the air the membrane moved backwards and the upper end of the lever moved forward, so as to press less strongly than before against the spring, thereby making

* The property of Léon Garnier, Esq., Director of Garnier's Institute at Friedrichsdorf, near Homburg, where Philipp Reis was formerly teacher of natural sciences.

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a less complete contact than before; and, by thus partially interrupting the passage of the current, caused the current to flow less freely. The sound-waves which entered the air would in this fashion throw the electric current, which flowed through the point of variable contact, into undulations in strength. Reis himself termed the contact-part of his telephone an "interruptor." That it was not intended to operate as an abrupt make-and-break arrangement, as some persons have erroneously fancied, is evident; firstly, because the inventor introduced delicate springs to give a following-contact (like that in Blake's well-known "transmitter"), and so prevent abrupt breaks from occurring; secondly, because abrupt breaks would have violated the fundamental principle to which he refers in the sentence immediately preceding his description of the instrument shown to the Frankfort Society, namely, that of creating tones whose curves were like the undulatory curves imparted at the transmitting end of the instrument; thirdly, because (in another article) he described his instruments as opening and closing the circuit in proportion to the sound-wave; which obviously an abrupt "break-and-make" apparatus without a spring-contact could not possibly do. The mechanism which Reis thus invented—and which is substantially alike in all his instruments—might be appropriately described as the combination of a tympanum with an electric current-regulator; the essential principle of the electric current-regulator being the employment of a loose or imperfect contact between the two parts of the conducting system; those parts being so arranged that the vibrations of the tympanum would alter the degree of contact, or occasion an approach and recession of the atoms of the two surfaces, and so vary the resistance offered at the point of contact to the flow of the current.

The particular form of the instrument shown at Frankfort in 1861, and described in the *Journal*, is somewhat different from the "ear." The description is taken from the *Journal*.

"In a cube of wood there is a conical hole, closed at one side by the membrane (made of the lesser intestine of the pig), upon the middle of which a little strip of platinum is cemented as a conductor of the current. This is united with the binding-screw *p*. From the binding-screw *n* there passes likewise a thin strip of metal over the middle of the membrane, and terminates here in a little platinum wire which stands at right angles to the length and breadth of the strip. From the binding screw *p* a conducting wire leads through the battery to a distant station." In the original instrument there is also an adjusting screw to regulate the contact, though this was not shown in the drawing in the *Frankfort Journal*.

The receiver used to reproduce the sounds transmitted by these telephones is also described in the memoir of Reis. It consisted of a steel needle surrounded by a coil of wire. This was at first set up—for the purpose of increasing the sounds by resonance—upon the top of a violin, as shown in Fig. 6; later it was mounted upon a pine-wood box, as in Fig. 7; to which still later a lid of thin pine was added, against which the listener could press his ear. The sounds emitted by such a wire during magnetisation and demagnetisation were well known before, but to Reis is due the discovery that other tones than the natural vibration-tone of the wire could be electrically imposed upon it by the varying magnetising power of the current traversing the surrounding coil. Reis explained the reproduction of the transmitted sounds by supposing a magnetic attraction between the atoms of the steel wire to work synchronously with the fluctuations of the current. He later devised a different receiver, in which an electro-magnet was provided with an elastically-mounted armature of iron attached to a light and broad lever, which it threw into vibrations corresponding to those of the original sound waves. With this apparatus, and a transmitter with a small curved-lever, in shape like that in the "ear," he was able (see Kuhn's "Handbuch der Angewandten Elektricitätslehre," 1866, p. 1,021), not only to reproduce melodies with astonishing exactness, and single words as in speaking and reading less distinctly, but even to transmit the inflexions of the voice expressive of surprise, command, interrogation, &c.

Considering how far these early researches were carried, it is remarkable that their historic value has been so greatly overlooked. The transmitters which Reis devised embody—though their mechanical design is less perfect and their performance consequently less certain—all the essential principles of the telephonic transmitters in use to-day, such as Blake's, Berliner's, and Crossley's. The receivers devised by Reis, more particularly the second form, anticipate every principle essential in the more modern and convenient receiver of Graham Bell, having an electro-magnet combined with an armature capable of inductive action, *i.e.*, made of iron, elastically mounted, and having an extended surface. Bell made the very great improvement of uniting these three qualities, essential to the armature, in one, by employing as armature a thin flexible iron plate. It is but just to the later inventors to add that both Bell and Edison have explicitly referred to Reis's prior work, Bell even going so far as to name the pages of "Kuhn's Handbook" from which the preceding reference is taken.

A HISTORY OF ELECTRIC TELEGRAPHY TO THE YEAR 1837.

BY J. J. FAHIE, MEMB. SOC. TEL. ENGS. AND ELECS.*

(CONTINUED FROM PAGE 120.)

Experiments on the transmission and velocity of electricity, to which the new discovery lent a fresh and fascinating interest, were now resumed. Daniel Gralath, early in 1746, was the first to transmit the shock to a distance, which he did by discharging a battery, composed of several jars, through a chain of twenty persons, with outstretched arms. In May, 1746, Joseph Franz, at Vienna, discharged a jar through 1,500ft. of iron, and in the following July, Winkler charged, as well as discharged, a battery of three jars through an insulated wire thirty ells long, and laid along the bank of the river Pleisse, whose waters formed the return half of the circuit.†

The Abbé Nollet, whose name is famous in the annals of this period, had meanwhile taken up the subject in France. He first, April, 1746, transmitted the shock of a Leyden jar through a chain of 180 of the Royal Guards at Paris, and soon after performed a grander experiment of the same kind at the Carthusian convent. By means of iron wires stretched between every two of the monks he formed a large circle of 5,400 feet through which he discharged his jars, with the result in every case that at the moment of discharge all the persons in the circuit gave a sudden spring, showing that the shock was felt by each at the same instant and to the same degree of intensity.

Lemonnier, the younger, also of Paris, employed still longer circuits composed of two thousand toises (12,780 feet) of iron wire laid along the ground, and, although some of the wire dragged upon wet grass, through hedges, and over newly-ploughed fields, the shock was in no way diminished, a fact which was then thought very surprising. In other experiments he made use of two large basins of water in the gardens of the Tuileries. In April, 1746, in the court of the Carthusians he so laid out two parallel wires of 5,700 feet each that all four ends were close together. Between one pair he placed a jar, and grasped the other extremities himself; then on causing the circuit to be completed, he could not distinguish any interval (so short was it) between the spark at the jar, and the shock through his arms ("Priestley," pp. 92—5).

Upon receiving an account of these performances from Lemonnier, our own distinguished countryman, Watson, took up the inquiry, and pursued it so successfully as not only to eclipse the achievements of his neighbours, but to gain for himself in after years the credit of being the first to propose an electric telegraph—an idea which, as we will presently see, is quite erroneous.‡ Watson's experiments were very numerous, and were carried out on a grand scale, under the auspices of a committee of the Royal Society, consisting of Mr. Folkes, Lord C. Cavendish, Dr. Bevis.

* The author reserves all rights of translation.

† Winkler had previously, in 1744, ascertained that the rapidity of an electric discharge was exceedingly great and comparable with the speed of lightning. He also, as the result of his experiments, concluded "that electricity could be transmitted to the ends of the earth, if a conducting body covered or insulated with silk be laid so far, it being only necessary to consider that there may be a certain amount of resistance to the transmission." "Thoughts on the Properties, Operations, and Causes of Electricity," Leipsic, 1744, pp. 146, 149.

‡ The suggestion has been claimed for Franklin and Cavendish, and with as little reason. It is time that writers on the telegraph ceased to bandy pretensions for which there is no foundation whatever.

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and others. As preparing the way surely, though unsuspectedly, for the first suggestions of an electric telegraph these investigations must ever possess a peculiar interest for telegraphists, and we therefore make no apology for presenting to our readers the following detailed account of them, for which we are indebted to Dr. Priestley's work, pp. 95—102.

Dr. Watson, who wrote a full account* of the labours of the Committee for the Royal Society, begins with observing (what was verified in all their experiments) that the electric shock is not, strictly speaking, conducted in the shortest manner possible, unless the bodies through which it passes conduct equally well. The circuit, he says, is always formed through the best conductors, though the length be ever so great—a most sagacious observation for the man and the time—

The first trials took place on the 14th and 18th July, 1747, on a wire carried from one side of the Thames to the other over old Westminster Bridge. One end of this wire communicated with the interior of a charged Leyden jar, the other was held by a person on the opposite bank of the river, who also held in his other hand an iron rod which he dipped into the water. Near the jar stood another person holding in one hand a wire communicating with the exterior coating of the jar, and in the other an iron rod. On dipping this into the water and thus completing the circuit for the discharge, the shock was instantly felt by both persons, but more strongly by him who stood near to the jar—because, as Watson rightly stated, part of the electricity went from the wire down the moist stone work of the bridge, thereby making several shorter circuits to the jar, but still all passing through the observer who stood near it.

The next attempt was to force the shock through a circuit of two miles at the New River near London. This was accomplished on the 24th July at two places, at one of which the distance by land was 800 feet and by water 2,000; and at the other, 2,800 feet of land and 8,000 feet of water.

The disposition of the apparatus was similar to that at Westminster Bridge, and the results were equally satisfactory. On repeating the experiments, however, the rods, instead of being dipped into the water, were merely thrust into the ground about 20 feet from the water's edge. The result was the same, as it was found that the shock was equally well transmitted. This occasioned a doubt whether in the former case the shock might not have been conveyed through the ground between the two rods, instead of passing through all the windings of the river, and subsequent experiments showed that such was the case. Other experiments followed at the same place, on the 28th July, when for the first time the wire was supported in its whole length by dry sticks, and on the 5th August, at Highbury Barn when it was found that dry ground conducted the electric virtue quite as well as water.

Finally, on the 14th August at Shooter's Hill, an experiment was made "to try whether the electric shock was perceptible at twice the distance to which it had yet been carried, in ground perfectly dry, and where no water was near; and also to distinguish if possible its velocity as compared with that of sound." The circuit consisted of two miles of wire, and two miles of perfectly dry ground, but one shower of rain having fallen in the previous five weeks. The wire from the inner coating of the jar was 6,732 feet long and was supported all the way upon baked sticks, and that which communicated with the outer coating was similarly insulated, and was 3,868 feet long. The observers placed at the ends of these wires, two miles apart, were provided with stop watches with which to note the moment that they felt the shock. The result of a series of careful observations was that "as far as could be distinguished the time in which the electric matter performed its circuit might have been instantaneous."

Not satisfied, apparently, with this result, the inquiry was resumed in the following year, when a series of trials was performed after the manner of Lemonnier's Carthusian experiment of 1746. On the 5th August, 1748, a circuit of two miles was formed at Shooter's Hill by several turnings of wire in the same field. The middle of this wire was led into the same room as the Leyden jar, and there Watson placed himself in the centre of the line, taking in each hand the ends of the wire, and noting the spark with his eye while he felt the shock in his arms. Under these circumstances the jar was discharged several times, but in no instance could the observer distinguish the slightest interval between the moments at which the spark was seen and the shock felt; whereupon it was decided that the time occupied by the passage of electricity along 6,138 feet of wire was altogether inappreciable.

In 1748 Benjamin Franklin performed his celebrated experiments across the Schuylkill at Philadelphia, and De Luc some months later (1749) across the Lake of Geneva. Franklin thus playfully refers to his experiments at the end of a letter to his friend and correspondent, Peter Collinson, of London, dated Philadelphia, 1748:—

"Chagrined a little that we have hitherto been able to produce nothing in this way of use to mankind, and the hot weather coming on, when electrical experiments are not so agreeable, 'tis proposed to put an end to them for this season, somewhat humorously, in a party of pleasure on the banks of the Skuylkil. Spirits at the same time are to be fired by a spark sent from side to side through the river, *without any other conductor than the water*—an experiment which we some time since performed, to the amazement of many. A turkey is to be killed for our dinner by the electrical shock, and roasted by the electrical jack, before a fire kindled by the electrified bottle, when the healths of all the famous electricians in England, Holland, France, and Germany are to be drank in electrified bumpers, under the discharge of guns from the electrical battery."*

As the words that we have italicised in this extract are apt to mislead, and indeed have misled, some writers into supposing that Franklin here describes an experiment akin to that of telegraphing without wires, from which so much was expected forty years ago, we quote the following details from Vol. 1, page 202, of Franklin's works, London, 1806:—"Two iron rods, about 3ft. long, were planted just within the margin of the river, on the opposite sides. A thick piece of wire, with a small round knob at its end, was fixed on the top of one of the rods, bending downwards, so as to deliver commodiously the spark upon the surface of the spirit. A small wire, fastened by one end to the handle of the spoon containing the spirit, was carried across the river, and supported in the air by the rope commonly used to hold by, in drawing ferry boats over. The other end of this wire was tied round the coating of the bottle, which, being charged, the spark was delivered from the hook to the top of the rod standing in the water on that side. At the same instant the rod on the other side delivered a spark to the spoon and fired the spirit, the electric fire returning to the coating of the bottle, through the handle of the spoon, and the supported wire connected with them." The experiment was, therefore, precisely the same as that of Watson across the Thames, the only difference being in the words used to describe it. In the one case the discharge is said to go out by the water and return by the wire, and in the other to go out by the wire and return by the water.

Notwithstanding the singular suggestiveness of all these experiments, no one up to this time appears to have entertained the faintest suspicion of their applicability to telegraphic purposes; or, indeed, to any useful purpose whatever. Thus Watson, in a letter to the Royal Society, says:—"If it should be asked to what useful purposes the effects of electricity can be applied, it may be answered that we are not yet so far advanced in these discoveries as to render them conducive to the service of mankind," but, he adds, "future philosophers may deduce from them uses extremely beneficial to society in general." This was in 1746, and with reference to his then recent ignition of spirits by the spark; but even after his brilliant experiments in the following years, of which we have just given an account, he does not appear to have formed any more hopeful view. We also find the great Franklin, who was always in search of the practical in science, positively expressing his disappointment in the letter just quoted at being unable to find any useful application of electricity.†

* "An account of the experiments made by some gentlemen of the Royal Society," &c., 8vo., London, 1748.

* "An electric battery, famous because it was once owned and operated by Benjamin Franklin, and other distinguished scientific men, has been in constant use at Dartmouth College for years, and is now employed almost daily for class-room experiments in physics. It was at one time in the hands of the celebrated Dr. Priestley, the discoverer of hydrogen."—(American newspaper.) Another interesting relic—Faraday's first electrical machine—is still in vigorous action at the Royal Institution, and was used by Dr. Gladstone to illustrate his Christmas Lectures in 1874-5.

† His suggestion of the lightning-conductor was not made until towards the end of July, 1750, for which he was indebted to an experiment of his friend, Thomas Hopkinson. This philosopher electrified a small iron ball, to which he fixed a needle, in the hope that from the point, as from a focus, he would draw a stronger spark. Greatly surprised at finding that, instead of increasing the spark, the point dissipated it altogether, he mentioned his failure to Franklin. On repeating the experiment, the latter ascertained, not only that the ball could not be electrified when a needle was fastened to it, but that, when the needle was removed and the ball charged, the charge was silently and speedily withdrawn, when a point connected with the earth was presented to it. Reflecting on this, Franklin conceived the idea that pointed rods of iron fixed in the air might draw down the lightning without noise or danger.—(Franklin's Complete works, Vol. I., page 172, London, 1806).

(TO BE CONTINUED.)

Eastern Electric Light and Power Company.—The new address of this company is 19, Great Winchester-street. Mr. W. Jackson is secretary.

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THE ELECTRICIAN.

TO CORRESPONDENTS.

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ANSWER TO CORRESPONDENT.

A. J.—*Next week. Diagram too late to be prepared for this week.*

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THUNDERSTORMS.

To the purveyor of short paragraphs a thunderstorm is next only in importance to big gooseberries, inland waterspouts, and great sea serpents. At certain seasons of the year he can count on a quarter column of jottings once or twice a week, collected from provincial sources, where lightning plays wantonly, unregulated and unchecked. Evidently he regards its vagaries as something designed for the supply of news in the dull season. From north, south, east, and west the actual mischief done, or the imaginary fright occasioned, by thunderstorms and their accompanying downpours are industriously gathered for every lover of the marvellous; but never by any chance do we get an intelligent or a discriminating detail that can be called instructive. The effects of lightning are interesting to the paragraph-monger only to the extent of the damage it does, and he reckons on the damage much as a gardener reckons on the benefits of rain, as part of the order of Nature, not to be criticised, much less meddled with.

Glancing over the scores of short notices relating to thunderstorms which enliven the newspapers during the summer months, the thoughtful reader cannot fail to be struck by the mechanical and fatalistic tone in which the narratives are couched. A house here, a church there, a barn in one place, a school in another, are more or less seriously stricken, and the tale of killed or injured is the inevitable appendage. But no matter how important the building or how serious the loss of life no mention is made of the commonest precautions having been taken to avert the disaster. A universal scepticism seems to prevail as to the efficacy of all artificial precautions, or else, what amounts to the same thing, a universal superstition against adopting them. Buildings, great and small, are left to take their chance, their only safety resting on the law of averages, which, if it foredooms a few, spares the many. The fatal blow will come some day, but meanwhile apprehension is hushed in uncertainty.

Now, as regards the greater portion of the accidents to which we are alluding, there can be no question that they are preventible, and this by means both simple and inexpensive. That these means are largely neglected is a fact within everybody's knowledge, and that they are generally effectual when not neglected may be certainly inferred from the accounts of these casualties making no mention of the safeguards having failed. It is true that they do sometimes fail, and from causes which have been commented upon many times in these columns; but in the majority of cases no precautions, perfect or imperfect, have been taken, and the accident is primarily due to that fact. Of course we must except from this sweeping statement the larger public buildings and all such as properly belong to the nation. But these, when all told, make up a comparatively insignificant total, leaving an immense number of isolated and conspicuous edifices to the tender mercies of the devastating element. We include the merely isolated as well as the conspicuous, because, judging by the evidence before us, isolation is as much a danger as loftiness—a barn or a farmhouse being as frequently struck as the village steeple or the town hall.

Upon the two last-named classes of buildings some show of lightning protection is occasionally visible, but nobody ever thinks it worth while to affix such appliances to detached buildings of low structure. Yet we strongly suspect there is just as much damage done to this class of building in Great Britain as there is to similar buildings in other countries where due precaution is more general because thunderstorms are more terrific there than with us, but certainly not so frequent. The protection needed is at once so easy and so cheap that no small building should be without it; and we think its presence would be far more common in this country if the public were disabused of a prevailing error that only, or chiefly, tall buildings are exposed to the risk of being struck. We are sadly in want of trustworthy statistics relating to these matters, and the newspaper columns, for reasons referred to above, are the last places from which the figures can be drawn. But, so far as the facts are known, tall chimneys, high spires, and lofty towers are most carefully looked after, not because of their special peril—though, of course, that is considerable—but because of the special consequences that would follow their being struck; whilst by far the larger number of casualties occur to structures of meaner pretensions.

It speaks well for the system of lightning protectors at present in use that, in spite of their notorious imperfection, they do serve their purpose fairly well, flagrant cases of failure and consequent accident in spite of them being comparatively infrequent. We are glad to see this subject is being taken up in a serious spirit by electrical engineers, who alone know the conditions under which a lightning conductor may be relied upon to perform its functions faithfully. It is a subject which the law is hardly competent to touch, even if

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the passing of a useful law were any longer possible for us. But public opinion may be roused to do what legislation is incapable of doing, and we should advise those whom it may concern to ply the public, first, with facts, which at this season of the year are plentiful enough, and then, secondly, with the lessons these facts teach, namely, that no building is exempt from danger where lightning is concerned, but that none need suffer if due precautions have been taken.

SIR EDWARD SABINE.

Sir Edward Sabine died at Richmond on June 26, at the age of 95. From *The Times* we learn that he was born in Dublin, October 14, 1788. His father was Mr. Joseph Sabine, of Tewin. He was educated at the Royal Military Colleges of Marlow and Woolwich, and obtained his first commission in the Artillery, December 22, 1803, receiving his captaincy in 1813. Sabine was made lieutenant-colonel in 1841, colonel ten years later, lieutenant-general in 1859, retiring with the rank of general in 1874. At a very early period of his career his interest was enlisted in physical science, and especially in the subject of terrestial magnetism. On the conclusion of the American war (1813-16), he was appointed, on the recommendation of the President and Council of the Royal Society, astronomer of the first expedition in search of the North-West passage, viz., the expedition commanded by Sir John Ross, in 1818, and on the return of that expedition, accompanied the second expedition of 1819-20, commanded by Sir Edward Parry, in the same capacity. In 1821-22 he was employed by the Government in conducting a series of pendulum experiments for determining the figure of the earth, at several stations at or near the Equator on the coasts of Africa and America, and in the following year, 1823, proceeded in the "Griper" to extend the series to Greenland, Spitzbergen, and Norway. In 1824 he was employed in publishing the results of these experiments. In 1825 he was appointed with Sir John Herschel the British members of a joint commission between the French and English Governments to determine the precise difference of longitude between the Observatories of Paris and Greenwich by means of rocket signals. In 1827 he was employed in determining by direct observation the difference in the length of the seconds pendulum at Paris and Greenwich, and of the magnetic force of the earth at the same stations. For many years after this, in order to verify his theories and complete his knowledge, he himself carried on a vast series of observations, both in terrestrial magnetism and on the acceleration of the pendulum in different latitudes in all parts of the globe, from the Equator to Arctic Circle. The results of these observations and of the experiments he made at the Royal Observatory and elsewhere were regularly communicated to the Royal Society and to the British Association, and gave a great impulse to systematic observations in these directions. In 1822 he gave the Bakerian Lecture of the Royal Society, "On the experiments to determine the amount of dip of the magnetic needle in London in 1821." In 1836 and 1837 he presented to the British Association an account of a magnetic survey of the British Islands and a report of the variations of the magnetic force in different parts of the globe. Again, in 1840, he still deals with the great subject of terrestrial magnetism, extending and giving precision to our knowledge of the vastly important question of the lines of declination and intensity on the surface of the earth. Thirty-two years later Sabine was working in the same direction, and in 1872 we find him bringing before the Royal Society his thirteenth contribution on the subject of terrestrial magnetism. A moment's thought will show the vast practical importance of such experiments. An accurate knowledge of the lines of intensity, of dip and inclination of terrestrial magnetism, ever shifting, even though slowly, is of the highest moment to all whose safety depends on the indications of the mariner's compass. Not, probably, that Sabine had any distinct idea of simply benefiting navigation by his researches; this is one of those instances of scientific research pursued for its own sake, from the mere desire of adding to an accurate knowledge of the multifarious phenomena of our wonderful universe, but which almost inevitably involves results of high practical value to humanity. In his report for 1838 Sabine concludes:—

"Viewed in itself and its various relations, the magnetism of the earth cannot be counted less than one of the most important branches of the physical history of the planet we inhabit; and we may feel quite assured that the completion of our knowledge of its distribution on the surface of the earth would be regarded by our contemporaries and by posterity as a fitting enterprise of a maritime people, and a worthy achievement of a nation which has ever sought to rank foremost in every arduous and honourable undertaking."

An immediate result of this report was that Captain James Ross was sent in command of the "Erebus" and "Terror" to make a magnetic survey of the Antarctic regions, and to plant on his way three magnetical and meteorological observatories at St. Helena, the Cape, and Van Diemen's Land. Not only so, but this and his other valuable reports gave rise to a series of observations in all our colonies and all over the globe as well as at home, the results of which completely changed the aspect of this vast department of science. The colonial observatories were for many years under the guidance of Sabine; and he reduced and published the results obtained at them as well as those of a general magnetic survey of the globe begun at that period under the directions of the Admiralty. Indeed, the firm foundations on which the science of terrestrial magnetism are now based, and the vast advances it has made in recent years, may be mainly attributed to Sabine's exertions. Sabine was elected to the Royal Society in 1818, was vice-president in 1850, and succeeded the late Sir Benjamin Brodie in the presidency in 1861. He held the latter post till 1871, when he lost his accomplished and congenial wife, whom he had married upwards of half a century before. She herself was the translator of Humboldt's "Cosmos," which Sir Edward edited in 1849-58. He was for many years an active member of the British Association, at whose meetings some of his most important papers were read, was its general secretary twenty-one years, and the presidential chair of which he filled in 1853. He was a member of the Royal Commission to inquire into the standard of weights and measures (1868), and was made a K.C.B. in 1869. He had the Prussian order *pour le mérite*, the Italian of Ss. Maurice and Lazaro, and the Brazilian of the Rose. In 1821 he received the Copley medal of the Royal Society; in 1826 the Lalande medal of the Institute of France; and in 1849 the Royal medal of the Royal Society. He was elected honorary or corresponding member of many of the principal academies and societies of Europe and America. As a scientific worker Sir Edward Sabine holds a high rank, and his name will ever hold a large place in the annals of science and the history of navigation.

WILLIAM SPOTTISWOODE.

On the day following the death of Sir Edward Sabine we were discussing the then dangerous condition of the President of the Royal Society. It must have been during the hour of our conversation that one of the brightest scientific lights that has adorned this or any other country passed away. A remark made by the gentleman with whom we were conversing concerning the critical condition of Mr. Spottiswoode will be accepted almost as a truism:—"His great services to science and to scientific men will not be realised till he is gone." Only those who knew him intimately knew his strength—knew how quietly and how unostentatiously he was accustomed to open his stores of knowledge for all who came to him for help. He seemed delighted if he could give pleasure, not only to his scientific friends, but to all with whom he was brought into contact. We are indebted to *The Times* for the facts in the following remarks:—The death of a President of the Royal Society in his term

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of office—especially since that became limited—has been rare indeed. True, both Newton and Banks died in their presidential chairs, but the former had filled the office for twenty-four and the latter for forty-two years. Mr. Spottiswoode was elected only four years ago. He was the type of a student of science almost peculiar to this country, one who does not follow science as a vocation, but as an avocation, who cultivates it from pure love in the leisure left him by the busy life of a man of business or affairs. We have had several notable examples of this class of investigator, but among living men we need only mention the names of Sir John Lubbock and Mr. De La Rue. Such men have done substantial service to science, and none more than the late President of the Royal Society, although in fields which are in the main accessible only to the esoteric few. But these services are none the less momentous or far-reaching on this account; they deal with the deepest principles which underlie all physical research. William Spottiswoode belonged to a very old Scottish family, which has produced several notable men since the time of the Archbishop of St. Andrews in the sixteenth and seventeenth centuries, while a branch of it has achieved in some of its members considerable prominence in the United States. He was born in London on January 11, 1825, son of Andrew Spottiswoode, brother to the Laird of Spottiswoode, and the then head of the printing business. After spending some time at Laleham at a school kept by Mr. Buckland, brother of Dean Buckland, and a severe disciplinarian, young Spottiswoode was sent to Eton, where, however, he stayed only a short time; he and his brother attempted some chemical experiments (in which detonation played a prominent part) at a time when science had no place in our public schools. No blame, however, it is admitted, was attached to the brothers, who were transferred to Harrow, then under the rule of the present Bishop of London. Here William Spottiswoode had the reputation of being studious and thoughtful, and, after a stay of three years, entered Balliol College, Oxford, in 1842, having obtained at Harrow a Lyon Scholarship. In 1845 Spottiswoode took a first-class in mathematics, winning in 1846 the Junior and in 1847 the Senior University Mathematical Scholarship. Although on quitting college he entered upon the active management of the business of the Queen's Printers, resigned to him by his father, still he gave lectures for a term or two at Balliol, and ten years later was examiner in the Mathematical schools. Mr. Spottiswoode was nearly as good a linguist as he was a mathematician, and so accomplished an Oriental scholar was he that he was urged to undertake an edition of a great work on Indian astronomy, on which he contributed a paper to the *Journal* of the Asiatic Society. During the thirty-five years that have elapsed since Mr. Spottiswoode left college, his life has been an unusually busy one. Mr. Spottiswoode's earliest scientific work consisted of five quarto pamphlets, published in 1847, under the title of "Meditationes Analyticæ," and since then scarcely a year has passed without a contribution from him to one or other of the branches of science in which he was interested. Many of these papers, as we have said, appeal only to specialists, and deal with abstruse mathematics; but in these, as in his more purely physical work, fellow-students, both in this country and abroad, admit he showed an intellect not only of the the highest training, but of rare clearness, penetration, and even originality. No one had an easier familiarity with the mysterious symbols of the modern mathematician, and some of the methods originated by him have become classical. Spottiswoode has been called the "incarnation of symmetry," and this feature of his mind comes out not only in his mathematical work, but in those beautiful researches in physics connected with polarised light and certain forms of electrical discharge with which his name is intimately associated. Indeed, his researches in these departments have in some respects all the merit of originality, and especially in connection with the exquisite phenomenon of polarisation his work, both as an investigator and expounder, takes the highest rank. It goes without saying that honours were showered upon Mr. Spottiswoode; our leading universities enrolled him among their "doctors," the Paris Academy of Sciences made him a corresponding member, while other foreign societies gave similar evidence of the estimate in which they held him. Finally, in 1879, he was chosen to the highest honour which science in this country has to bestow—the presidency of the Royal Society. Here he filled a position of no small difficulty with the greatest tact. His annual addresses were models of what such productions should be, while his beautiful country seat at Sevenoaks was famous on both Continents for its cultured hospitality. Mr. Spottiswoode's relations with the workmen in his large establishment were of the best and friendliest, and these will feel that in him they have lost a real friend. Thus, as we have said, his death will be felt as a grievous loss in many quarters, most of all among that wide circle to whom he was endeared as a true and ever-sympathetic friend. In 1861 he married the eldest daughter of the late Mr. William Urquhart Arbuthnot, a distinguished member of the Indian Council. He died at the early age of fifty-eight of an attack of typhoid fever.

CORRESPONDENCE.

ELECTRIC RAILWAY.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: As that system of electric locomotion in which the rails are utilised as conductors appears to be increasing in favour, perhaps the following might be applied to advantage by some enterprising electrician:—

In driving a current through a great length of rail, it is obvious that a large amount of energy is lost, not only from leakage attendant on imperfect insulation, but also from humidity and corrosion. In order to meet these difficulties it has already been suggested to send the current automatically through only one portion of the rail at a time, but as this suggestion does not appear to have been practically applied to any great extent, I submit the following scheme to your notice, should you think it worthy of appearing in your invaluable columns:—

FIG. 1

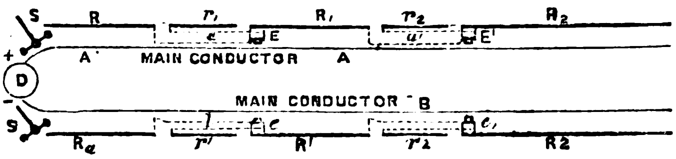
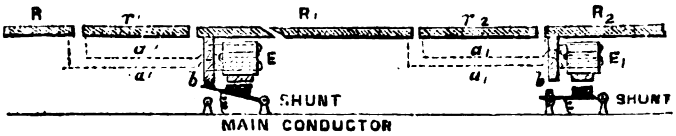


FIG. 2



Let the rails be divided into sections such as R R_1 R_2 r_1 r_2 (Fig. 1). The current is conveyed by two insulated conductors, A_1 B_1, placed between the rails. Supposing a locomotive to be on section R R_a, the current is shunted—by means of a hand shunt S—from the conductor A to R, through the wheels of the engine to the motor, thence to R_a and through S_1 to the conductor B. The engine will now move forward to section r_1 r^1, and the current will now flow from R_1 through an auxiliary conductor a, round an electro-magnet E, entering r at y, thence through the motor to r^1, through another auxiliary conductor l, round an electro-magnet e, thence through R_a back to the dynamo. But in flowing round E the current magnetises it, and the electro-magnet attracts a shunt, connected to the main conductor A, which makes contact at b (Fig. 2) with the rail R_1. A similar arrangement connects R^1 with B.

The moment the locomotive reaches R_1 R^1, the sections R R_a $r_1 r^1$ are disconnected, and, on closing the shunt S, are completely cut out of the circuit. But, as communication is now established between R_1 and R^1, a current will still flow round the electro-magnets E e, although through a different

circuit, and retain the contact already made between the shunts and the sections R_1 R^1. As the locomotive proceeds it will in time reach r_2r'', another pair of electro-magnets and shunts will put R_2R'' into communication with the conductors; the sections R_1R^1 are retained in the circuit until R_2R'' are reached, and then they are cut out as well as the subsections r_2r''.

The object of the smaller sections r_1r_2, &c., and the auxiliary conductors, is to produce sufficient magnetism in the electro-magnets to help the shunts in contact with the major sections, until the locomotive, having reached these, and thus completed the circuit, shunts a portion of its current round the electro-magnets.

One objection to this system might be, that the trains could only travel in one direction on the same line, owing to the automatic arrangement, but this could be easily remedied by using a return line.—Yours, &c., JOHN TOURTEL.

32, Springfield-place, Leeds, June 12, 1883.

ON THE WINDING OF ELECTRO-MAGNETS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Professors Ayrton and Perry having directed their experiments towards the discovery of the best mode of winding a given length of wire on an iron bar to give the strongest electro-magnet for the same current, have just supplied me with part of the information of which I have been in search. We pigmies in electrical erudition are apt to take it for granted that the giants (such as the above mentioned professors) have already discovered and are familiar with all the laws and rules which should govern electricians in the most advantageous construction of instruments, and sometimes we suppose that it is only due to our comparative ignorance that we are unacquainted with these rules.

Curious to say, I had noted with other plans of winding electro-magnets those mentioned by Professors Ayrton and Perry in *Phil. Mag.* for this month, or rather I had noted the desirability of investigating the respective effects of winding so as to give the electro-magnet the form (nearly) of (i) an hour-glass and (ii) of an egg. Something in the construction of some noted induction coils led me to believe that this question has already been investigated, but as I could not find any published account of the laws regulating these effects, I was anxious to find them out for myself.

I am also desirous of investigating the effect of winding in another manner, which appears advantageous.

Suppose that the reel of an electro-magnet will hold 40 turns of wire of a particular gauge in each layer. I propose, instead of winding one wire 40 times in each layer, to take 40 wires, and wind them, side by side, until the reel is full, bringing out the 40 inside ends through a slit in the core. It is obvious that the 80 ends may be joined up in many ways, so as to vary the resistance of the electro-magnet, and if the 40 wires are joined up in parallel circuit, the resistance will be enormously reduced. For example, a coil which, wound in the ordinary way, has a resistance of 400 ohms, may be wound so as to have 40 parallel circuits of 10 ohms each, and (following the law that the joint resistance of any number of wires joined parallel to one another is equal to the reciprocal of the sum of the reciprocals of their respective resistences) their joint resistance will be only ·25 ohm, instead of 400 as when connected in series, whereas the current passing through any one of them will be the same as in series. As the curve at passing through any turn of wire in the coil will be the same in both cases, I conclude that the magnetic effect will also be the same, whereas the total resistance of the coil may be enormously reduced.

As the resistance of an electro-magnet should always bear a certain proportion to the total resistance in circuit in order to obtain the maximum effect, it would appear that the above means of varying the resistance of the electro-magnet for the various resistances of different circuits may be applied with good effect. In telegraph instruments, Mr. R. Sabine has shown that the speed of transmission diminishes with the resistance in circuit, and that the resistance of the receiving instrument has a great influence on the speed, so that it would seem that this plan of reducing resistance might be adopted with advantage, especially where there are a number of electro-magnets in circuit. I propose also to try the effect of variation in gauge of the wires near the poles and towards the neutral line of the magnet. This mode of winding, in fact, will suggest an endless variety of combinations in joining up the wires, so that the resistance may be varied within a very wide range, to say nothing of differential and partly differential methods. I write this with some diffidence, as I may have made some gigantic error in principle, so I shall only sign myself, yours, &c., CACARUCAS.

MEDICAL ELECTRICITY.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I do not think that Mr. Bennett, p. 109, would be at all "trespassing on your valuable space if he attempted to demonstrate the physiological actions" of electricity. For my own part, I quite hold with him that *electricity*, either continuous or alternating, has powerful medical action, though *magnetism* has little or none. That is where the difference comes in. In one case there is a supply of energy directed upon the nerves and tissues; in the other case the action, if any, is merely an obstruction to the internal energies of the body itself. I used to think that I knew a good deal about medical electricity, but my estimate has resembled a condenser charge, constantly lowering. Unfortunately, the whole subject has been too much left in the hands of quacks and of a few medical men who have made it a speciality, and it is difficult to obtain any reliable scientific information.

There is the subject of intermittent, or coil, currents. Can Mr. Bennett give real information as to their action? I have had a growing conviction that it is not an electric action at all, but what may be called an internal friction, a muscular exercise set up by the contractions and relaxes resulting from the successive electric charges. Now this is very important, as it would dispose of a great deal of mysticism, and make coil construction and use a very simple matter.—Yours, &c.

J. T. SPRAGUE.

TESTING LIGHTNING CONDUCTORS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Having completed the experiments promised in my last, I have now the pleasure of sending the results to you. I will number the conductors as before.

The chimney head on which No. 1 is fixed was under repair last week. While that was proceeding I took the opportunity to make a test of the conductor from spear to earth. For this purpose an insulated No. 16 copper wire, which I will call l_3, was taken to the top and fastened to the spear, about the middle, after filing a bright surface thereon. The other end was in connection with the terminal of the Wheatstone bridge. Previous to fixing this wire, its resistance was measured and found to be ·53 ohm. One of the wires hitherto used for testing the earth of this conductor, which I may call l_1—using the same letters as "A. J." in your issue of last week—is soldered at a height of 125·5ft. from the top, measures 22·5ft., and has a resistance of ·0697, say ·07 ohm. The wire to the main water earth l_2 measures 11ft., and has a resistance of ·03399, say ·03 ohm. All the wires were insulated. The battery consisted of four Leclanché cells, and the galvanometer had coils of 2, 10, and 1,000 ohms resistance. Ten ohms gave the best indication. The resistances of the leading wires were thus:—

l_1 = ·07 ohm.
l_2 = ·03 „
l_3 = ·53 „

The instruments, &c., being ready the first test was made with the + current passing from bridge through l_3 to spear, and back through conductor, earth, and leading wire l_2. I got a resistance of 1·75 ohm, less $l_3 + l_2$ = 1·19 ohm. The

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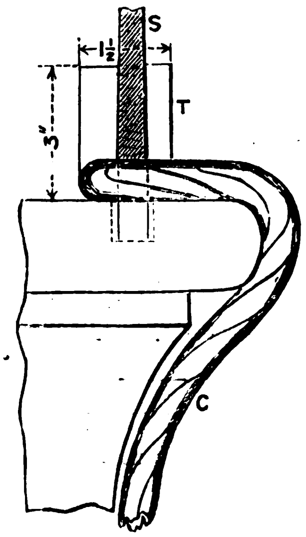
second test was made through l_3, spear, conductor, and l_1, without earth, when I got 1·54, less $l_3 + l_1$ = ·94 ohm. The third test showed the resistance of the earth and that part of the conductor below l_1, taken through l_1, conductor, earth, and l_2, to be ·27, less $l_1 + l_2$ = ·17 ohm net.

By the first test the conductor has a resistance of 1·19 — ·17 = 1·02 ohm, and by the second it is ·94 ohm. The earth resistance is nearly the same as when last tested. Calculating the resistance of 126·5ft. of ⅝in. conductor (the length in circuit), composed of seven wires of No. 11B. W.G., I find it to be about ·01446 ohm for pure copper; and the mean of the resistances found above is about 68 times greater. This indicates a fault somewhere, the most likely place being the junction of the copper rope with the spear. I questioned the man working at the top as to how the fastening was made, and found that the spear was let in to the stone cope for some distance, and run up with lead. The copper rope was then put once round, and the free end spliced into the rope in the form of a loop. I felt that this joint should be made good, but was somewhat at a loss to know how to do it. Ultimately I hit upon the following plan :—A thin piece of sheet copper was bent into the form of a tube 1½in. diameter and 3in. high. A piece was cut out of the side to bridge over the conductor, and the inside was tinned. The lower end of the spear and loop of the conductor were then polished with a file and emery cloth, and the copper tube placed in position. The bottom and side joints



were now packed with a bit of soft clay. S the spear, T the tube, and C the conductor, in the sketch, illustrate the arrangement.

At this stage I tested the conductor again, more out of curiosity than otherwise, and found that the resistance had increased to 17·1 ohms. I thought the man had altered or loosened the testing wire on the spear, and made him re-adjust it without altering the resistance, so I concluded that in cleaning the loop he had broken part of the slight connection which must have existed between spear and conductor, and so it proved to be. A pot of molten lead was now sent up, and some resin. The latter was put into the tube first, after it the lead. When the first ladleful was poured in I depressed the keys, and found the resistance had fallen to ·80 ohm through l_3, spear, conductor, and l_1.

On the completion of the operation I tested the conductor carefully, with the current flowing as before through the same leading wires, and got the following result, viz.:—

Conductor and earth ·80 — ·56 = ·24 ohm.
Conductor alone ·64 — ·60 = ·04 ohm.
Earth alone ·29 — ·10 = ·19 ohm.
Conductor + earth ·04 + ·19 = ·23 ohm.

The lead joint had therefore reduced the resistance from 68 to 2¾ times that of pure copper; 2¾ is still very high, but several considerations lead one to expect the resistance to be greater than the calculated one. Besides impurities in the copper, the strands are very much thinned by oxydation and 25 years' exposure to the weather. Oxydation has also insulated the wires from each other; so that the testing wire l_1 which was soldered to the outside strands is not likely to be in metallic contact with the central one, thus throwing it out of circuit. There is also the probability that a wire may be broken, although such was not noticed. For these reasons I am inclined to believe that the result of this test is satisfactory.

With regard to the conductors Nos. 2 and 3, I have tested these again, partly under the conditions suggested by your correspondent "A. J." The battery was the same as that used with No. 1, but the leading wires were different. The latter had a combined resistance of ·98 ohm. The galvanometer indicated a difference in both conductors where the poles were reversed. For No. 2 I got with the + current to bridge 1·44 ohm, and with the — current 1·60, mean 1·52 ohm. 1·52 — ·98 = ·54 ohm is, therefore, the earth resistance of this conductor. With No. 3 the + current to bridge gave 1·13; and the — current 1·33, mean 1·23 ohm. 1·23 — ·98 = ·25 ohm for the earth of No. 3.

I may add with reference to the earths of Nos. 1 and 3 conductors that I had the impression that the water pipes to which they are fixed were separate and distinct from the main water supply of the town. But I now find that, although the pipes are worked as different systems, I have overlooked the fact that they are more or less metallically connected through apparatus in the works. The main water pipe was not, therefore, a proper battery earth with which to test them. I have tried the gas pipes, but they also give low resistances, and I feel sure they are in metallic connection with the water systems, and short circuiting somewhere. I must therefore make new tests with artificial earths made with copper plates.

No. 2 is earthed to an iron pipe in an old deep well, not in use, and not in contact with the other water systems, so far as I am aware. The distance from l_1 to the well is 113ft., and there are two soldered splices included in the circuit, but this difference will hardly account for the much greater resistance of this conductor earth. It appears to be due rather to the fact that it is not in metallic connection with the other two, and, therefore, a truer earth.—Yours, &c.,

Greenock, June 26, 1883. T. L. P.

THE GRAMME RING.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: The experiment made by Dr. Higgs with a Schuckert machine, in describing which he states that he obtained nearly the normal E.M.F. when exciting from one side only of the ring, entirely agrees with the remarks I made in a letter to you of recent date.

Dr. Higgs's experiment would tend to prove that if the core of the ring can be *saturated* by induction from magnets on one side only, the E.M.F. for a given speed is practically at a maximum for that particular ring, which is precisely what I intended to convey.

My chief reason for writing to you now is that Mr. Mordey has attained such different results in his repetition of the experiment. That he should obtain but 1 per cent. of the normal E.M.F. when using one pair of magnets is, I consider, a most extraordinary result, and I for one should be glad to have further particulars of the experiment, if Mr. Mordey will favour us with them.

The only explanation I can imagine for such a result is that Mr. Mordey had all the field magnets *in position*, when *exciting* one pair only; if so, of course, the armature was magnetically short circuited by the idle pair.—Yours, &c.,

Cambridge-street Works, Birmingham, June 27, 1883. W. B. SAYERS.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY.—The traffic receipts for the week ending 15th June, 1883, were £1,490, after deducting the "fifth" of the gross receipts payable to the London Platino-Brazilian Telegraph Company.

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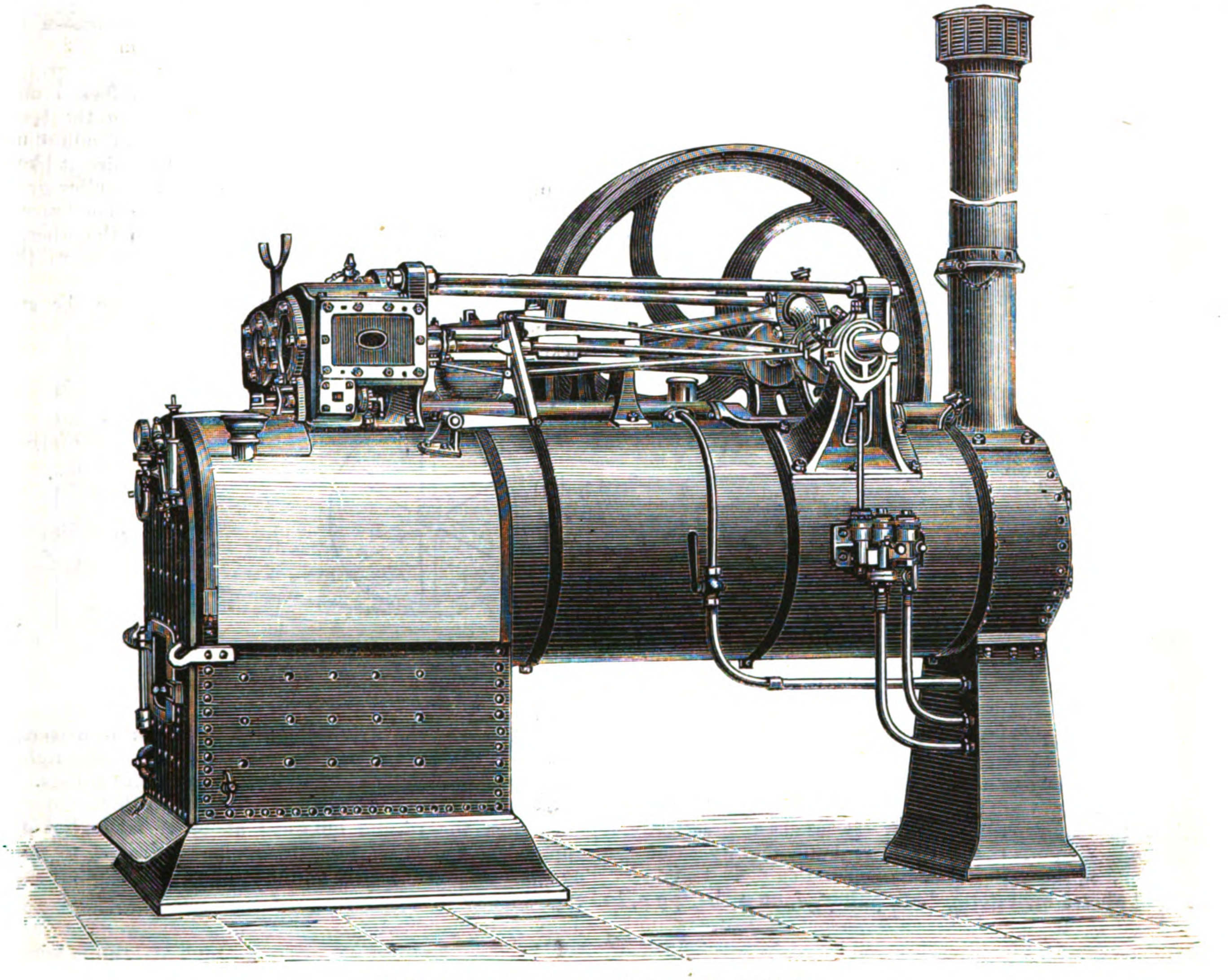
THE HOLBORN RESTAURANT INSTALLATION.

We have already referred to this installation of the Edison system, and herewith give, with illustrations, a somewhat more detailed account of the machine room. The want of space has interfered with the arrangement, which would no doubt have been different had the accommodation been ampler. Two semi-portable engines, of 16 horse-power each, by Messrs. Ransomes, Head, and Jefferies, of Ipswich, are used to drive the Edison dynamos. The two engines are placed side by side. Our illustration shows one of the engines. They each have two $9\frac{3}{8}$in. cylinders with a 12in. stroke, and the speed is 140 revolutions per minute. Each is fitted with Ransomes' patent automatic governor expansion gear, which we have more than once described. In this arrangement the governor acts directly upon the expansion slide valve by means of a link motion, and its action is to admit steam to the cylinder at full boiler pressure in proportion to the work on the engine. The results obtained with this gear in electric light work have been satisfactory. At some trials made at the South Kensington Museum with a similar engine the coal consumption was found to be 2·74lbs. per hour per indicated horse-power, a good result for high-pressure engines.



Ransome's Engine—Holborn Restaurant Installation.

There is on trial at this installation one of Samper's Pulley-Grippers, for the following description of which we are indebted to Mr. M. F. Adams, the representative of Mr. Samper in England. The object of this invention is to increase the adhesion of the cords or belts employed for the transmission of motion, avoiding or nullifying the tension between the intermediate shafts, and guiding the cords or belts accurately. By the ordinary system the cords or belts embrace only half the circumference of the pulleys if these are of equal size, and less than half of one of them if they are unequal; but since the vibration of the belts while running causes them to lose their grip on a portion of the circumference embraced, it results that the adhesion is much less in practice than is expected, and in the majority of cases, being insufficient for the transmission of power, recourse has hitherto been had to two methods for establishing the adhesion and for supplying the want of points of contact between the cords or belts and the pulleys. These two methods are:—(1) keeping the belts very short, and consequently tight; or (2) producing this same tension by means of a loose pulley called a "Belt-Tightener," which derives its name from its use. The imperfection of these two methods of producing adhesion originates many evils, such as the heating and destruction of the intermediate shafts, of the bearings, and of the belts, loss of power, waste of fuel, stoppage of operations, and impossibility of turning angles, &c. It is these defects and inconveniences that Mr. Samper proposes to remedy and prevent by means of his system. By the above-mentioned methods, hitherto employed for producing tension, not only is the desired rotary motion imparted to the shafts, but they are also subjected to a lateral strain, whilst Mr. Samper claims that in his system the rotary motion alone is produced without deflecting the shafts. The patentee employs a loose "pulley-gripper," which is flanged, while the intermediate pulleys are not. The pulley-gripper is mounted on one or two arms independent of the intermediate shafts, or else on arms which are fitted on the shaft itself, but loose, and secured between collars.

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By one of these two general methods this system can be applied in all existing cases. The "following" side of the cord or belt is picked up by the pulley-gripper, which is brought up close to the intermediate pulley, touching it if desired, but not pressing against it, and is then moved along

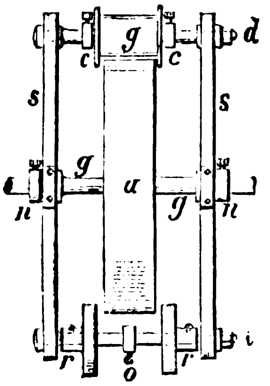

FIG. 1.

a circumference concentric with that of the pulley until it nearly brings into contact the "following" and "leading" sides of the belt, and in this manner the cord or belt embraces nearly the whole circumference of the pulley. By these means the *contact* of the belt or cord with the which has been applied a pulley-gripper, *g*, fitted on the arms *s s*. These arms are fixed loose on the shaft *g g*, and are held in position and kept from rubbing against the pulley by means of the collars *n n*. The arms *s s* are adjusted by means of two spindles, *d i*, which have on each end two washers and one nut. The pulley-gripper *g* has flanges for guiding the belt, and is kept face to face with the pulley, or in whatever position may be desired, by means of the collars *c c*.

The pieces *r r* on the spindle *i* are for guiding the belt, in case the apparatus is used for stopping the motion, in order that when the pulley-gripper is drawn away, and the belt falls slack, it may not come off the intermediate pulley. These pieces need not be rotary, and are useless when the apparatus is not required for stopping the motion, or when the arms of the pulley-gripper are in close proximity to the pulley. The hook *o* is for hanging a weight to support the apparatus, or for attaching a cord to fix or tighten it, if required.

Fig. 2 shows an arrangement in which the pulley-gripper *g* is placed so as to cause the greatest possible adhesion on the pulley *a*, and the pulley-gripper *g* is regulating the tension of the belt without obtaining the maximum of adhesion on the pulley *x*, because this pulley does not require it like the other. On the pulley *a*, the flanges of the pulley-gripper face the pulley, and on the pulley *x* the flanges embrace the pulley, because the pulley *x* is narrower than the other, and by that means a belt can be used the entire width of pulley *x*.

Fig. 3 shows an arrangement for increasing the speed.

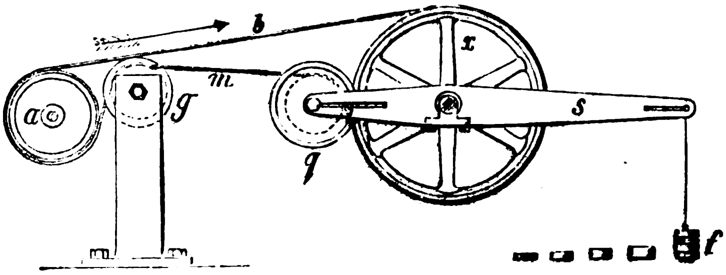

FIG. 2.

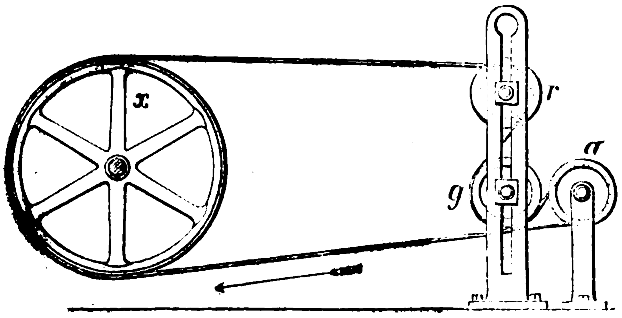

FIG. 3.

driving pulley is increased from the ordinary average of 180° to as much as 325°, thus causing the adhesion of the belt to the pulley to a point far beyond the centre of the shafts, and as the pulley-gripper is always kept close against the intermediate pulley, it secures practically a steady adhesion of the belt throughout the whole of the circumference theoretically embraced.

Fig. 1 shows an intermediate pulley, *a*, on a shaft, *g g*, to

The pulley *x* is the driving pulley, pulley *a* is driven; the roller *g* is the pulley-gripper, and the roller *r* is a tightener running in the vertical slot of the arms of both rollers.

We have witnessed a series of trials with this gripper, and have seen the results obtained at other trials, but as the apparatus is to be tried under various conditions, we need do no more at present than call the attention of electric light engineers to it.

THE DISCOVERY OF THE ELECTRIC LIGHT.

Professor Silvanus P. Thompson writes under the heading of "Historic Notes on Physics" in *Nature*:—"In looking through an old volume of the *Journal de Paris*, I came across the following entry, for the date 22 Ventôse, An X. (March 12, 1802), which clearly relates to an exhibition of the electric arc light:—

"'Le citoyen Robertson, auteur de la phantasmagorie, fait dans ce moment, des expériences intéressantes, et qui doivent sans doute avancer nos connoissances sur le *galvanisme*. Il vient de monter des piles métalliques, au nombre de 2,500 plaques de zinc, et autant en cuivre rosette. Nous parlerons incessament de ses résultats, aussi que d'une expérience nouvelle qu'il a faite hier avec deux charbons ardens. Le premier étant placé à la base d'une colonne de 120 élémens de zinc et argent, et le second communiquant avec le sommet de la pile, ils ont donné, au moment de leur réunion, une étincelle brillante, d'eune extrême blancheur, qui a été apperçue par toute la société. Le citoyen Robertson répétera cette expérience le 25.'

"The individual who thus came before the public was named Etienne Gaspard Robertson, a name suggestive of Scotch descent. He was better known for his 'Phantasmagoria,' exhibited a few years later in London. Of this invention a notice appears earlier in the volume from which the above passage is taken; and in an earlier volume of the *Journal de Paris* in the month '*Fructidor*, An VIII.,' there occurs a mention of some of his experiments on the *couronne de tasses* of Volta.

"It is worthy of casual notice that in the number where Robertson's 'Phantasmagoria' is advertised, the very next advertisement on the page is one of an exhibition to be given by Citoyen Martin at the Hôtel de Fermes, wherein, as part of a

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'spectacle extraordinaire et amusant de Physique,' &c., was to be shown 'l'expérience du télégraphie plus rapide que la lumière d'un effet extraordinaire et amusant.'

"The usual date given for the invention of the electric light by Sir Humphry Davy is 1809, but I was aware that earlier notices existed both in Cuthbertson's 'Electricity' (1807) and other works. I was also under the impression that some earlier reference to the matter existed in Davy's own works. The finding of this notice in the *Journal de Paris* induced me to consult the early volumes of the *Philosophical Magazine* and of *Nicholson's Journal*.

"In the *Philosophical Magazine*, Vol. IX., p. 219, under the date February 1, 1801, the following passage occurs in a paper by H. Moyes, of Edinburgh, in which experiments with a voltaic pile or column are described :—

"'When the above column was at the height of its strength its sparks were seen in the light of the day, even when taken with a piece of charcoal held in the hand.'

"In the *Journal of the Royal Institution*, Vol. I. (1802), Davy describes (p. 106) some experiments on the spark yielded by the pile, and states : 'When, instead of the metals, pieces of well burned charcoal were employed, the spark was still larger and of a vivid whiteness.' On p. 214 he describes and depicts an 'apparatus for taking the galvano-electrical spark in fluids and aëriform substances.' This apparatus consisted of a glass tube open at the top and having a tubulure at the side through which a wire, tipped with charcoal, was introduced, another wire, also tipped with charcoal, being cemented in a vertical position through the bottom.

"But earlier than any of these is a letter printed at p. 150 of *Nicholson's Journal* for October, 1800. This letter is entitled 'Additional Experiments in Galvanic Electricity, in a letter to Mr. Nicholson.' It is dated 'Dowry-square, Hotwells, September 22, 1800,' and is signed by Humphry Davy, who at that time was assistant to Dr. Beddoes at the old Philosophical Institution in Bristol. The letter begins thus :—

"'Sir: The earlier experimenters on animal electricity noticed the power of well-burned charcoal to conduct the common galvanic influence. I have found that this substance possesses the same properties as metallic bodies in producing the shock and spark*, when made a medium of communication between the ends of the galvanic pile of Signor Volta.'

"In none of these extracts, however, is anything said of the properties of the *arc* as a *continuous* luminous spark. These were made known in Davy's later researches. Yet the electric light attracted attention, as we see, before the special property of continuity was observed."

* Here Davy adds a foot-note : "The spark is most vivid when the charcoal is hot."

ELECTRICITY v. GAS AT THE SOUTH WALES WORKS.

[The following correspondence from a local contemporary is so very interesting, and the facts stated of so practical a nature, that the wider the publicity obtained the better for the success of electric lighting.—Ed. *E.*]

TO THE EDITOR OF THE LLANELLY AND COUNTY GUARDIAN.

Dear Sir: In reference to the paragraph appearing in your issue of last week with regard to the electric lighting at the South Wales Tinplate Works, might I ask you to find room when you next go to press for the following report which I have received from Messrs. Morewood and Co.—Your faithfully, Jno. C. Howell.

[Copy.]

"South Wales Steel, Iron, and Tinplate Works,
"Llanelly, June 7th, 1883.

"J. C. Howell, Esq., Llanelly.

"Dear Sir: I am sorry to hear that a report has been spread to the effect that the electric light was not successful in our works, and this morning I was surprised to learn that it was rumoured that we contemplated returning to gas.

"I feel it only fair to yourself and Messrs Crompton and Co. to contradict these statements, and to give you some information respecting our experience of the incandescence electric light plant supplied to us by Messrs. Crompton, and you are at liberty to make what use you think well of such information.

"We started the first installation of fifty lamps on November 1st, and after about a month's trial were so satisfied with it both as to cost and the superior quality of the light as compared with gas, that we ordered a second dynamo machine, cables, &c., which we started about the middle of January, giving us a total of one hundred lamps. Since then they have been working regularly every night except, of course, Saturday and Sunday nights, and during the last two months twenty of the lamps have not been required, as the days are now so long. Our two assorting rooms, tin houses, annealing and pickling rooms, cold roll room, and to some extent our mills, are lighted by the electric light, and the only trouble that we have had in any department has been in the tin houses, where we find the dust from the bran and the smoke from the grease pots collect upon the lamps, which have to be wiped off almost every evening. I have little doubt that this can be overcome by suitable glass covers, but even if it cannot be, the expense of wiping the lamps in the tin house is so small as to be of no importance.

"Some may naturally ask you why we have not put up the electric light in our iron forge and steel works. We shall ultimately do so, but the life of iron is so uncertain, and if we convert our iron forge into an extension of our steel works, or use it for other purposes, the alterations might entail new arrangements of the lamps. Besides this we make our own gas, and very naturally do not like to discontinue the use of the retorts until they are worn out, but we certainly shall not renew them.

"As to the comparative cost of the electric light and gas, there can be no question that for an equal candle-power the electric light is the cheaper if we pay 3s. 9d. a 1,000 cubic feet for gas ; and even when making one's own gas, as we do, I am doubtful whether the electric light is not the more economical of the two, in addition to which we have a superior quality of light.

"Six months' experience is too short a time to enable me to give anything but an estimate of the cost of electric lighting, as some parts of the machines only require renewing once in every two or three years. In fact, as yet the cost of renewals has been almost nothing, except in lamps. I, however, estimate that over a series of years this item of expense will not exceed £60 per annum for 100 lights, exclusive of lamps, and this is confirmed by the reports of others, who say that 10 per cent. upon the cost of the plant will quite cover repairs, and £60 is a great deal in excess of 10 per cent. upon the cost of our plant. Taking this sum as the expenditure on repairs, the cost of the electric light will be as follows in cases similar to our own, where there is spare steam at night :

	£	s.	d.
Wages	62	0	0
Lamps	90	0	0
Repairs, &c.	60	0	0
Oil and stores	13	0	0
	225	0	0
Less work done by engineer	41	6	8
	£183	13	4

I deduct the above amount for the work done by the engineer. He has nothing to do except to oil the bearings once or twice during the night, and can turn rolls, screws for the mills, &c., in a lathe driven by the same engine as the dynamos ; in fact, it is an advantage in more ways than one to give him this work to do, as it prevents him from going to sleep and so neglecting oiling the machinery, as well as the saving in wages.

"This cost is for 100 lamps of 17 candle-power for a year, using them on an average five nights a week for 14 hours in the winter six months, and nine hours in the summer six months; this gives a total of 2,990 hours, during the whole of which we have 1,700 candle-power of light for the sum of £183 13s. 4d.

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"What would an equal light cost in gas at 3s. 9d. a 1,000 cubic feet? We cannot calculate on burning less than one cubic foot of gas per hour for every three candles'-power; so to get 1,700 candle-power for 2,990 hours, we should burn 1,694,300 cubic feet of gas, costing £317 14s. 7d., against £183 13s. 4d. for the same light if supplied by the incandescence electric system.

"If we had to raise steam for generating the electricity, we should have extra expenses in coal and labour as follows:—Every ten lamps require one horse-power, so we should want 10 horse-power for our 100 lamps, which, with a fairly good boiler and engine, would consume 30lb. of coal per hour, or 40 tons per annum, which at 5s. a ton equals £10. In addition to this we cannot expect the engineer to do any turning, as he has to fire the boiler, and there are other small expenses to be met, bringing the extra cost through having to raise steam to £56 6s. 8d., giving a total for 100 lamps of £240 per annum, against £317 14s. 7d. for gas.

"I am sorry that the incorrect report as to the result of our adoption of the electric light has compelled me, in justice to yourself and Messrs. Crompton and Co., to enter in any way into the discussion going on between the advocates of gas and electric lighting, but I feel that after what has been said silence on my part would be misconstrued.—Yours, &c.,

(Signed) "J. H. Rogers.

"P.S.—I have purposely omitted the question of interest on capital in the case both of the electric light plant and gas plant, as they must necessarily vary in different works. I have, however, omitted to debit gas with any charge for repairs to pipes, burners, &c., which is considerable in any rooms where acid is used, and will fully make up for any advantage in interest in favour of gas."

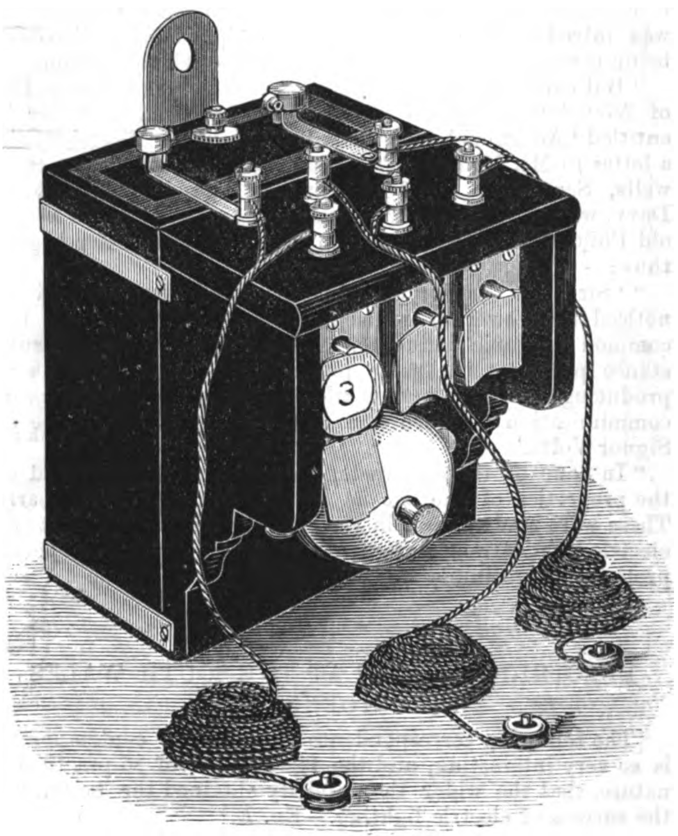
FISHERIES EXHIBITION.

The electric lighting at this exhibition is at length fairly complete, and we suppose will in future be seen at work. As is our custom we shall illustrate the machinery used so far as it has not been noticed by us before, and hence do not attempt to give a complete account of the work at present. It may not be out of place here to comment upon a stupid letter which appeared in the *Gl be.* The author of the letter tries to get up a scare because of non-duplication of plant, and hints that the breaking of a belt will lead to serious accidents. There is but one variation for the name of writers of this sort, they are either knaves or fools, and it is high time evenhanded justice was meted out to them. Unfortunately the damage effected by such writers cannot be repaired, inasmuch as neither technical journals nor common sense can reach the people who accept as containing some truth the statements of the writers. We agree with Mr. Proctor, that the scientific wisdom of the writers to our daily press is deplorable. Any rubbish is put into the papers, frequently corrections are not inserted. We will ask a series of questions in answer to the letter referred to. Is there one, or more than one steam engine, driving only one, or more than one dynamo? If there are—as there are—more engines and more dynamos than one, then more than one strap must break before *all* the lights are put out. The breaking of one strap might affect one circuit, but it would not affect all. We might to better purpose try to get up a scare because only one locomotive, as a rule, is put to one train.

To our subject, however, for we cannot take the trouble to call attention to every ridiculous flight of fancy perpetrated through the columns of the daily press. The portion of exhibition lighted is seven acres in extent. Over 25 miles of wire have been used, 56 dynamos generate the electricity, the apparatus being lent and exhibited by 15 firms. Messrs. Davey and Paxman supply the engine power. They were asked for 1,000 h.-p., but it is found that this was insufficient, and the engines will be driven hard to indicate 1,300 or more h.-p., so that some 4,000 incandescent lamps and 280 arc lamps may be used. Woodhouse and Rawson illuminate the vestibule with 350 of their lamps, supplied by an Elphinstone-Vincent machine. Siemens and Co. have arranged over 1,000 Swan lamps, supplying the current from two alternating Siemens machines—and have so arranged the circuits that alternate arches only are lighted from the same machine, so that should a strap break only one half, and these alternate lamps, would go out. Besides the Swan incandescent, Messrs. Siemens use four of their own arc lamps. The Jablochkoff Company lights several courts, as do Brockie lamps from a Gramme machine, while others are lighted by Lea lamps, also getting current from Gramme machines. The Gülcher Company has some 600 Crookes incandescent lamps supplied by Gülcher machines. Mr. Lever is lighting the dining room with twenty-eight of his arc lamps. It will thus be seen that we have here not only a grand display of apparatus connected with fishing, but one of the finest electrical displays yet made. Mr. Gooch, assisted by Mr. Henry, has in charge the electrical engineering of the exhibition.

COMBINED BATTERY BELL AND ANNUNCIATOR.

The annexed figure represents an exceedingly compact arrangement, in which a single cell is combined with an electric bell and annunciator in such a way that several



pushes and double wires may be attached to the bell and battery, and the annunciator will indicate from which push the bell is being rung. The arrangement is an improvement on the combined battery and bell brought out by the British Insulite Company, which we illustrated in a recent number. In that arrangement, although any number of wires could be attached to the combination, there was nothing to indicate which was the active wire. In the present improved design by the same makers there is added three drop shutters, exactly similar to those used in the Edison telephone switch-board. On this annunciator board is fastened a single insulite sealed cell, and below the drop shutters an electric bell, in which the hammer and magnets are all included under the bell dome. On the top of the board are three pairs of terminals, to which three double wires are attached, ending in the usual push. The arrangement is especially intended for offices and

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domestic work. Any one can fit it up. The battery cell has a very low resistance, and as the electromotive force acting on the total circuit is small, both the bell and the annunciator magnets have to be wound specially for the purpose. This electrical part of the arrangement was constructed by the Telephone Construction and Maintenance Company, and the advantage of employing their form of drop shutter is that, even supposing the shutter to have fallen, it is possible to see by the chattering of the drop catch which push is signalling.

PRACTICAL TELEPHONY.

(CONTINUED FROM PAGE 137.)

The switch bell referred to on page 137, so connected up that the ringing key will act whether the telephone is hung up or not, is shown by Fig. 26. The path of the current in ringing up is as

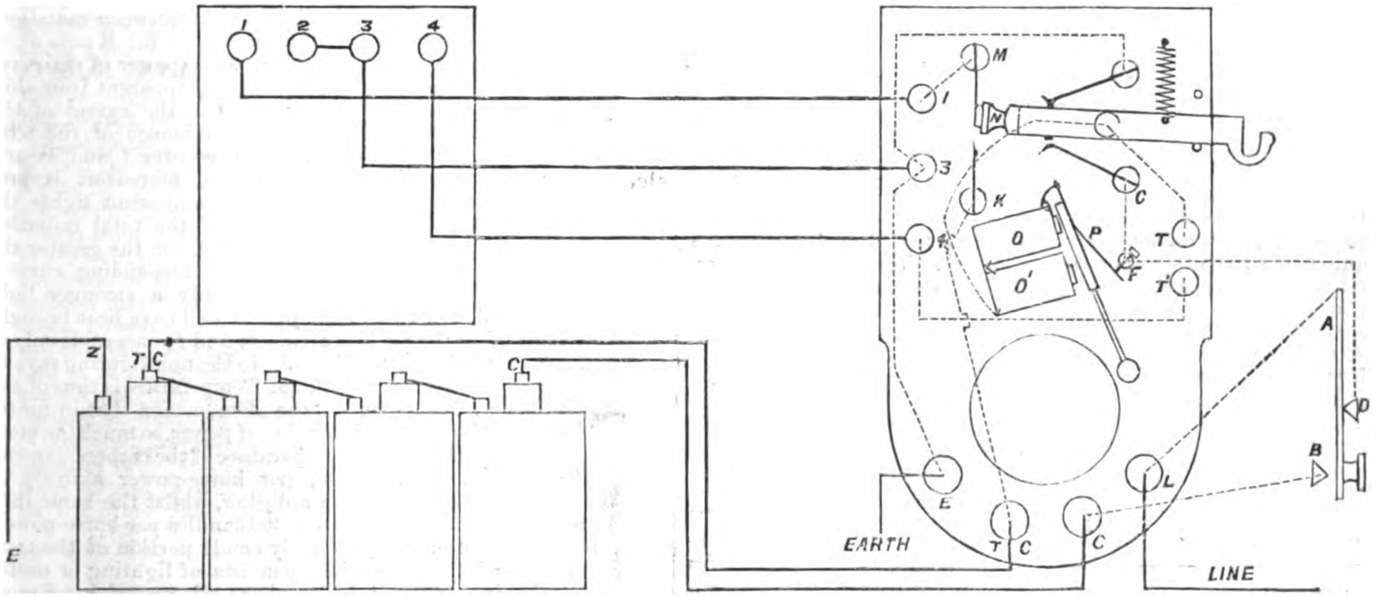

FIG. 26.

follows:—Battery carbon, terminal C, contact point B, spring A, terminal L, to line.

The passage of the arriving current is as follows:—Terminal L, spring A, contact D, bell contact point F, spring P, coils O O_1, switch hook lever, upper contact spring, to E.

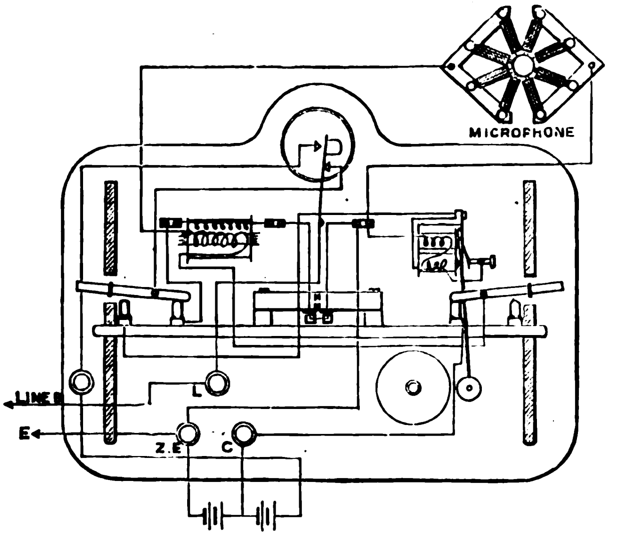

FIG. 27.

When the telephone is being used the path is the same as far as the bell contact point F, whence it goes to spring C, which is now in contact with the switch hook; thence to terminal T, through telephone, other terminal T, terminal 4 to transmitter, returning by terminal 3, and to earth.

A bell of this description, having two ringing keys as mentioned on page 137, was illustrated in *The Electrician*, No. 13. Vol. X., p. 299.

GOWER BELL INSTRUMENT.—This is the form adopted or use by the Post Office. The diagram of connections for these instruments without a relay is shown by Fig. 27 and with a relay by Fig. 28. The transmitter is a microphone of the radial type, and the receiver consists of a powerful magnet, both poles being utilised, two ear tubes, similar to speaking tubes, being fitted close to the diaphragm. The speaking is certainly loud, but somewhat lacks distinctness, and the tubes cause a sound similar to that heard in a shell when held to the ear.

JOHNSON TRANSMITTER.—This instrument is also used in this country to a certain extent, the microphone being the novel part of the arrangement, and gives excellent results. It consists of three carbon blocks, B, B_1, and B_2, Fig. 29, having two carbon pencils, A A_1, freely suspended between them. A secondary coil is employed as usual, and is shown at D. The current (using the accepted terms to convey the idea more clearly) passes from the battery F through the primary of the coil D, and thence to the block B_1, where it is divided, one half passing by the pencil A and the block B_1, the other half by the pencil A_1 and the block B_2, after which the divided current reunites in the wire G, which is connected to the opposite pole of the battery. When the transmitter is in use, the risk of a break of circuit is reduced by exactly one half. If the pencil A, for example, should break contact, the whole of the current—instead of one half—would pass through A_1, and no effect would be noticed in the telephone. But it is still possible that both pencils may break con-

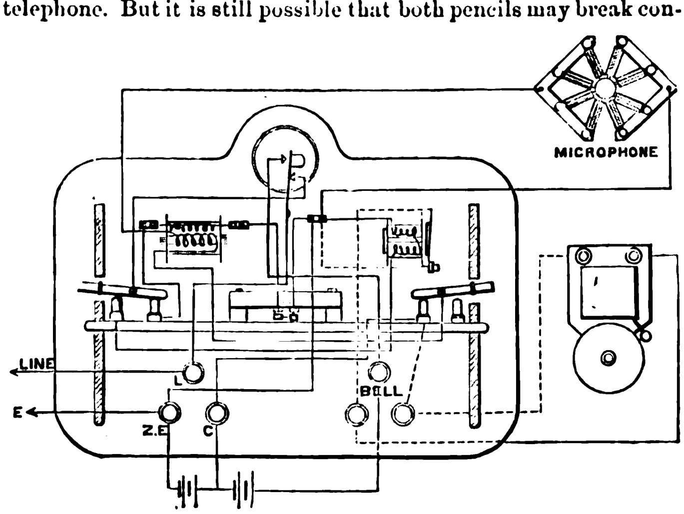

FIG. 28

tact together, and it is to avoid the result of this unanimity that the more ingenious part of the invention has been made. This consists of the shunt C, in which is inserted a resistance coil, C_1, the total resistance of the shunt being a little less than the total resistance of the microphone. The amount of current passing through the microphone and the shunt respectively is inversely proportionate to their respective resistances. It follows, therefore, that slightly more than one half passes through the shunt under ordinary circumstances, while the balance passes through the microphone. If now, in consequence of the impact of sound

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waves or from any other cause, the resistance of the microphone is varied, the proportion of current passing through the shunt will be varied also. Thus, if the resistance of the microphone is reduced, the amount of current passing through the shunt is decreased. If, on the other hand, the resistance of the microphone is temporarily increased, or if its conductivity is broken, then the amount of the current passing through the shunt is increased, or the whole of the current is diverted through it. It will follow from this arrangement that the undulations of the line current are very considerably modified, and that the extreme variations are altogether eliminated, the result being more distinct articulation in the telephone, and freedom from the defects of buzzing, humming, or rattling noises. The ordinary Bell telephone is used as a receiver.

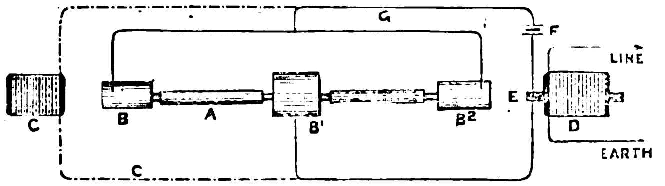

Fig. 29.

Adjusting Bells.—It will be necessary to see that all connections (see Fig. 25, p. 136) are tight, screw-post P, and screw *b* firm, and not shaking about, hold the hammer head D against the bell C, then adjust the screw *b* so that it all but touches the platinum point on spring *a*. See also that the armature *c* is quite clear from touching the poles d d_1. When the hammer is released the spring should draw the armature back, and the platinum point should make firm contact with the screw *b*. It sometimes happens that a bell rings badly from the spring not setting the armature back strongly enough. In order to know if this is the case, press with a wire the armature away from the poles lightly whilst the bell is ringing. If the ringing improves the spring and armature must be taken off, and the spring set out a little close to the fixed end. If the ringing improves when the wire is pressing the amature against the poles, the spring is too strong, and must be set in a little.

(TO BE CONTINUED.)

ON INCANDESCENT LIGHTING.*

BY WILLIAM SIEMENS.

(CONCLUDED FROM PAGE 119.)

There exists absolutely no difficulty in improving this system still further in the direction of higher illuminating power should a practical necessity arise for it. The firm of Siemens Brothers and Co. in Charlottenburg, for instance, who set a particular value in possessing in their incandescent lighting system lamps of most varied illuminating power, requiring similar E.M.F. and colour, makes, for example, 100 volt lamps of 130 candle-power. A short time ago a part of the Kochstrasse was experimentally lighted with such lamps, and the result was that the light about corresponded to that of the improved gas lighting in the Leipziger and Friedrichstrasse.

It is apparent from the table given above that the sectional areas of the carbons increase in quicker ratio than the illuminating powers and surfaces, and, as an increase of the durability is connected therewith, it follows that in an incandescent light system with lamps of different luminosity the weaker claim attention in a higher degree than the stronger, and it is therefore to be recommended as much as possible to give the preference to strong lights. As the E.M.F. at which the whole system is adjusted is chosen with regard to the least luminous lamp, so by leaving out these we can use higher candle-powers, and thereby attain a whiter light and greater economy.

It follows further that the advantage of the lamps of low E.M.F., which consists in the larger diameter and the greater durability, disappears still more, compared with lamps of higher E.M.F., the greater one makes their illuminating power. Thus, for example, the diameter of the Swan lamp carbon is 0·25mm., whilst the diameter of the 25 candle lamp of Siemens and Halske amounts to 0·27mm. This is particularly of importance when considering the lighting of large rooms.

The explanations previously given were made upon the assumption of identical temperature, materials, and substance. I will now enter into further particulars respecting these matters. For a certain work performed by the current E C there corresponds a fixed radiation. This radiation may be of very different kinds. Its character consists in an undulating movement of the æther, and the quality of a ray is determined by the length of its undulation or vibration, whilst its intensity depends upon the greatness of the amplitude. According to the extent of the undulation, dark lighting and chemical heat rays are distinguished. The maximum of the heating power lies in the dark rays. The quality of a ray only depends upon the temperature. The temperature has a two-fold influence on the character of the ray. Firstly, the intensity of each single ray is increased, and secondly, with higher temperature we obtain new rays of shorter length and of greater refrangibility. A white glowing body contains more red rays than when it is in a red glowing condition. According to Draper, all bodies begin at the same temperature (525deg.) to give forth the first lighting rays.

If a solid body is heated to a certain temperature, it will give forth a mixture of the most varied rays, from the longest waves to the shortest, which correspond to this temperature. The extent of this radiation will depend, however, upon the extent of the amplitude of the single rays, and this again is connected with the power of emission of the surface of the radiating body. According to Dulong and Petit there exists between radiation, temperature, and power of emission the relation : $R = m\,d^t$, in which R represents the total radiation, m the power of emission, and d a constant. The more important part, apparent from this, which t plays as regards m in reference to the extent of the radiation, is determined by the twofold influence of the temperature, as already mentioned. The greater t and m are, the greater is the total radiation, which, moreover, is proportional to the radiating surface. For incandescent lights the values t and m, in so far as the extent of the total radiation depends on them, are not of real importance, for the greater the total radiation the greater will be the corresponding current power (E C). By this means, therefore, only a stronger light would be produced, and this might just as well have been brought about by increasing the surface area. m and t concern us only in so far as the proportion of the lighting to the non-lighting rays in the total radiation changes with them. Temperature is thus of the greatest influence. This explains the phenomenon that in incandescent lamps, with a certain absorption of power, so much the more light is obtained the higher the temperature of the carbon filament. Thus one obtains, for instance, per horse-power scarcely 70 candles when the filament has a red glow, whilst the same in a white glowing condition gives over 300 candles per horse-power. It is, however, but a comparatively small portion of the total radiation in this latter case which consists of lighting or useful rays, and the incandescent lamps share this wastefulness more or less with all other artificial sources of light. Tyndall has given some data on this point. In his experiments he used a solution of iodine in sulphuretted carbon, which has the property of absorbing the lighting rays, but lets through the dark ones. From the proportion between the total radiation and the portion let through is estimated the proportion of lighting rays. This proportion amounts, for instance, in the case of an oil flame to 3 per cent. of the total radiation, in that of a gas-flame to 4 per cent., in a glowing white (heated) platinum spiral to 4·6 per cent., in an electric arc light to from 10 to 11 per cent. Thus, for this favourable light the useless portion of the radiation amounts to 90 per cent., and 90 per cent. of the work performed by the current E C is spent in the production of dark heat-rays. The economy of the carbon incandescent lights will be found between that of platinum and that of the arc light.

A question of interest is whether, assuming identical temperature for radiations of different substances, the proportion of the dark to the bright heat rays is a different one. This question as yet has been but little studied. If one heats in a furnace a piece of glass and a piece of iron to the same degree, on being taken out the iron will radiate a bright light, whilst the glass scarcely gives any perceptible light, though the temperature of both is the same. As the glass, however, on account of its great capacity for absorbing dark heat rays in the exchange relation between absorption and emission, is inclined to the radiation of dark rays, one can readily suppose that the difference in the radiation of light between iron and glass lies not merely in the differences of the total power of emission, but also in this, that glass, contrary to iron at the same temperature, sends out dark rather than bright rays. Exact experiments on this point are difficult.

Observations with a Maxim lamp showed, first, that a certain illuminating power corresponds to a fixed amount of work (E C). After a time, however, the illuminating power decreases without decrease in the resistance of the carbon, and, consequently, without E . C changing, the total radiation, however, in unit of time remaining constant. One might explain the fact by supposing the influence of the current to change the molecular character of the surface, and that this transformation resulted in an increased capacity of emission. A falling of temperature (as $R = m\,d^t$) would result, and consequently a

* Translated from the *Electrotechnische Zeitschrift*, March, 1883.

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diminution of illuminating power. At the same time, one would suppose that by the proportional strengthening the current, or by the application of more work, the earlier temperature and luminosity of the filament could be re-established. Such, however, is not the case, for the increase of the illuminating power necessitates a disproportionately strong augmentation of power expended. Therefore, the carbon is at first more economical for the production of light than in the second state.

It is very difficult to determine the influence of surface change, having no means of bringing carbons to exactly the same temperature.

The importance of temperature is universally known. How high this temperature should be can only be shown by experience. I have mentioned that, assuming the lamp to last a certain time, the temperature of carbons of large diameter can be higher than those with small diameter. Corresponding to the difference of the temperature, the economy of the different systems of lamps varies, and from 100 to 200 candles are obtained per h.-p. I am thoroughly convinced that the incandescent light is susceptible of improvement, and certainly important advances are to be expected in the employment of carbons which can stand a higher temperature. It appears to me very inconsistent to expect the incandescent light to prove a formidable rival to the arc light. The field of action for the incandescent light lies, in fact, only where the arc light cannot be used.

That lamp is not the best with which, by the application of a certain amount of work, we can momentarily produce the most light; but the preference will be given to that which—assuming a fixed duration—is capable of bearing the highest temperature.

It is sometimes also thought that the size and form of carbon is a criterion of the economy of a lamp. Some maintain that the thickness of the carbon is desirable; others, again, are of the opinion that it cannot be too thin, and so on. All these assumptions, however, are erroneous. As I have already made prominent, the sole questions are those of temperature and surface, and it is a matter of perfect indifference how this surface is shaped, whether it belongs to a good or to a badly conducting carbon, or what the form of section.

Although specific resistance exercises no influence on the quantity of light obtained for the power E C (in which temperature and capacity of emission are taken as constant), yet, on the other hand, the proportion between C and E depends upon it. The work performed on one lamp is $= C^2 w$ or $\frac{E^2}{w}$.

For, constant illuminating power, diameter, length, and temperature is

$$C^2 w_s = \frac{E^2}{w_s} = \text{const.}$$

The connection between C E and w_s (the specific resistance) is expressed hereby.

On the ground of economy in the conductor a higher specific resistance will thus be advantageous, though the advantage is not great, as E increases in a far smaller degree than w_s.

A carbon with rectangular section has a larger surface than the same length with same sectional area of a circular carbon, and at the same temperature the radiation from the larger surface will surpass that from the smaller surface. To obtain the same surface the circular carbon must be lengthened. Then luminosity and durability are equal in both cases, as is E C, but R in the round carbon is greater than in the rectangular, because of greater length, thus making E greater in one case and C in the other.

The round form is to be preferred, as for the same work and durability we obtain greater economy by using a higher E.M.F.

The form of the Edison lamp cannot, therefore, be considered a suitable one. The sectional area of the 16 candle-power lamp is a rectangle whose sides are about 0·1· and 0·2mm. long. A circular-shaped filament with the same surfaces might be about $\frac{1}{5}$ to $\frac{1}{4}$ longer, using a correspondingly higher E.M.F. The same holds good in a yet higher degree of Cruto's hollow carbon shown at the Munich Exhibition. We may say, then, that form of sectional area is the best which gives the smallest circumference for a given sectional area. And this is the round form. For conductors this rule must be reversed.

I have now submitted the last of the points to which I desired to call your attention. It was not at all my intention to give you a complete survey over all the details of this extensive region, but my object was only to call some attention to matters of pressing importance which are of weight in judging the value of this kind of light. By what has been said the direction of progress and the method by which progress may be facilitated is indicated. Improve the carbons to bear a higher temperature, and give a surface favourable to the radiation of lighting or useful rays. Further, advances must also be made in the attainment of a high vacuum.

In conclusion, I would mention that endeavours are being made to diminish the cost of the conductors, which even for lamps requiring high E.M.F. is considerable. It is considered that about three amperes will be carried properly by one square mm. sectional area of copper, which is sufficient for three of the stronger lamps taking 100 volts of E.M.F. Currents of high E.M.F. can by means of a suitable apparatus be transformed into currents of lower E.M.F. at the place of consumption. Let us imagine, for example, a Gramme ring without any of the external magnets, covered with thin wire, through which the current is sent. With motion the magnetism of the ring rotates. Now, if on the ring there is a second coil of thick wire in this there will be a continuous current of lower E.M.F., which may be collected from a commutator rotating together with the first, but in such a way that the connecting lines of the two pairs of brushes stand perpendicular to each other. Thirdly, by the application of a kind of induction apparatus the currents can be automatically changed in direction. In this case alternating currents are sent through the conductors.

I content myself here with mentioning these different methods, the improvement of which may be of importance for incandescent lighting.

THE FAURE ELECTRIC ACCUMULATOR COMPANY (LIMITED).

The second ordinary general meeting of the shareholders of the abovenamed company was held at the Cannon-street Hotel last Tuesday, under the presidency of M. Philippart. The secretary (Mr. Herbert Canning) having read the notice convening the meeting, the report and accounts were taken as read.

M. PHILIPPART then addressed the meeting, his remarks being interpreted by the solicitor (Mr. J. T. Campbell). Referring to his arrest, M. Philippart stated that he had been accused out of spite in connection with old questions pending with the Belgian Government as to certain railway matters. Persons engaged in business similar to that of the Company, but with other systems, would endeavour to profit by his arrest, but by great precaution and efforts he had been able to maintain the situation as it was. All the agreements which he was entering into and about to enter into with the Government and other persons in France still remained to be carried out by him as soon as the question connected with his arrest was settled in Belgium, which he believed would take place within fifteen days, and he believed it would terminate in in the way most favourable to himself. As conveying an intimation of what he had been doing while under arrest the following extract from *L'Evénement*, of June 26, was read:—"The Electrical Tramcar—We were present to-day at a most interesting event. At half-past three in the morning a tramcar belonging to the Omnibus Company left the Place des Nations (formerly the Place du Trône) loaded with forty passengers. The car passed over the rails of the exterior boulevards. In an hour and five minutes it arrived at the Place de l'Etoile, and five minutes later at Ranelagh (Passy). No horses, no steam, no compressed air, no noise. The few people who were about stopped apparently astonished at the sight of the car moving noiselessly along without horses. The electricity which was stored in Faure's accumulators placed under the seats of the car moved a shaft which transmitted the movement to the wheels by means of a chain Galle (endless chain). From Ranelagh the car and passengers returned to the place from whence they started, having performed a journey of thirty kilometres (more than twenty miles) over perhaps the most difficult route in Paris over more than half of which the gradients vary from 0·01 to 0·058 per metre. At the crossing of the Boulevard Rochechouart the gradient is not less than 4 centimetres per metre, and there the car was stopped and started again with ease. According to technical experts who were present this must have required at least 20 horse-power. The gradient of the Avenue Wagram, 400 metres in length, with an incline of 0·035 per metre, was accomplished at the rate of six kilometres per hour, to the amazement of all present. At the Place de l'Etoile, and after the car had crossed the points placed on a very sharp curve, the enthusiasm became general, for an ordinary tramcar, fully loaded, had gone 30 kilometres, at an average rate of 11 kilometres per hour, over a difficult route, in a bad state of repair, and with hastily constructed machinery, by the means of 2 tons of accumulators. Here, indeed, is what is likely to revolutionise the whole system of traction of omnibuses, tramcars, and even railways. It is stated that 20 tons of accumulators would suffice to transport a hundred passengers from Paris to Marseilles, at the rate of 100 kilometres an hour, without stopping. The interesting experiment was carefully watched by the engineers of the Orleans Company and the Chemins de fer de l'Etat. MM. Massillon and Clark, directors of the omnibus company, were there also, accompanied by their traffic managers, but, strangest of all to relate, this important experiment was conducted by Simon Philippart himself!—yes, Philippart *ipse*. The day after the judges at Brussels set him at liberty he lighted up the *salons* of the Liberal Association of Brussels, then he came to Paris and organised the experiments above mentioned. Last night he left for London. Decidedly the shareholder in the company 'La Force et la Lumière' who has been vindictively prosecuting him in Brussels would have done better to have let him work on."

A translation from an article in *La Ville de Paris* of the 25th inst. relating to the same experiment was also read.

Continuing, M. PHILIPPART said that experiments had been made in London, but never with such success. He then observed that there were now 600 tramcars in Paris, or what might be considered equivalent to that number. They all carried fifty passengers each; the cars were heavier than those in London. The cost of the *traction power* of each car in Paris came altogether to about sixty francs a day, whereas by adopting accumulators this cost would not exceed twenty francs per car per day. Accord-

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ing to the accounts of the Company each tramcar earned a profit of about twelve francs a day. Each car required fourteen horses during the day.

Mr. TURNER questioned the utility of the remarks, and suggested that the meeting should proceed at once to business.

The CHAIRMAN expressed his readiness to act in accordance with the wishes of the meeting.

Mr. TURNER thought the shareholders should see whether there was any money to carry out the works. Judging from the accounts there appeared to be no money to carry them out.

The CHAIRMAN remarked that the Company had no longer anything to do in England, the shareholders having approved of the sale of the residue of the English patents to the Sellon Company, having a preponderating interest in the French company instead. That company's patents were to be worked in France, and as the income of the Faure Company was to come from the working of the French patents, he thought it necessary that the shareholders should be informed of what was being done in France.

The CHAIRMAN stated that the experiments that were now being made in Paris were for the purpose of proving to the French people the value of these accumulators. There was no difficulty whatever in their having sufficient capital to carry out the matter in Paris as soon as they had shown that the accumulators possessed the advantages claimed for them.

Mr. TURNER wished to know the meaning of the accounts having been signed by the chairman "with a reservation, the nature of which I shall explain at the general meeting."

The SOLICITOR, on behalf of the chairman, said that on one side of the accounts there was an item "amount paid on 25,427 shares forfeited, of which 18,000 have been re-issued, £50,854." There was also on each side of the account, viz., on the debit side in the capital account and on the credit side among sundry debtors, the sum of £50,854 "for calls due on forfeited shares." With regard to these forfeited shares, these were standing in M. Philippart's name, shares belonging to the Société La Force et la Lumière, on which more than £50,000 had been paid. M. Philippart was desirous of assisting the Faure Company, and he considered that by allowing those shares to be forfeited on which more than £50,000 in hard cash had been paid by him, it would be, as it were, replacing the £43,000 which had been expended for the English patents and for working expenses, and the proposal he made to the Faure Company was to allow his shares to be forfeited. This was agreed to, but M. Philippart made it a condition that, as he was giving up those shares, representing £50,000, he should not be asked to pay the remaining calls due on them. The *procès verbal* did not properly explain the agreement which was come to; M. Philippart said, "When I give up my shares to the Company, in order that £50,000 of its capital may disappear, it is understood that I shall not be called upon to pay any future calls on those shares."

Replying to Mr. Turner, the SOLICITOR added that M. Philippart considered that he had made a present to the Company of that £50,000.

The SECRETARY stated that the 18,000 re-issued shares were re-issued to the Société la Force et la Lumière as £5 paid, with a responsibility on them of another £5.

A SHAREHOLDER observed that in point of fact nothing had been paid on those shares.

The SECRETARY replied that there was no necessity for this at present. He reminded them that an agreement was entered into by which the Company had to pay La Société la Force et la Lumière £200,000, and that society had taken those 18,000 shares, £5 paid, equal to £90,000, instead of cash.

The SOLICITOR stated that the issue of these shares to the Société la Force et la Lumière was merely carrying out an agreement which the shareholders had approved.

Mr. TURNER observed that he had not understood that such an agreement had been ratified.

The SOLICITOR, replying to Mr. Turner, said that M. Philippart was the only creditor of the Société la Force et La Lumière, and the largest shareholder. The shares that had stood in that gentleman's name really belonged to the Société la Force et la Lumière, which now held three-fourths at least of the shares of the Faure Company.

The SECRETARY, also in reply to Mr. Turner, stated that the shares standing in M. Philippart's name were forfeited in January, and that then there were no more shares left in his name but the number necessary for his qualification.

The SOLICITOR stated that the Company had become interested in three-fourths of the whole of the profits of the French Company.

After a few remarks from Mr. STAPLES, the Chairman said that the whole of his fortune was embarked in the concern, and he had the greatest hopes of its success. By means of electricity he calculated that the cost of traction of the Paris cars might be reduced, and if they could only make arrangements with the Tramway Company to give them half the profits they saved they would have at least twenty francs on 600 cars a day in Paris. That was £500 a day, and that was only as regarded the City of Paris. He was very sanguine that he had solved this question. He considered that the experiment he had made was eminently satisfactory; carried out in the presence of official persons competent to judge. He proposed to go on with those experiments for the next fifteen days, and he believed that the tramcar owners would become so satisfied that there ought to be no difficulty in getting them to agree to give the electrical company a portion of the large amount they would save by the use of electricity. Traction on railways, he pointed out, was very much easier than on roads. With regard to lighting by electricity, also, he maintained that it could not be carried on to any extent or in any satisfactory way without the use of accumulators. All he had got to do was to go on with perseverance.

In reply to Mr. Turner,

The CHAIRMAN stated that supposing he were convicted, the position would be very difficult, as he did not see how the affair would go on in France without him, but that his conviction appeared to him most improbable, seeing that the charges against him were unjust; notwithstanding the gravity of the charges made against him, he had been unconditionally set at liberty upon the insignificant bail of £600.

Mr. STAPLES then suggested that the meeting should be adjourned without passing any resolution, and that until the next meeting was held there should be no further call made.

M. CADIOT, in reply to Mr. Campbell, stated that the £23,000 in the hands of the Company when the present Board took office had been used in connection with the Company's business, and in subscribing to shares in other French companies as arranged by the agreement approved by the shareholders. The full particulars explained, however, could be seen on reference to the accounts at the office.

Mr. TURNER stated that the old directors, before they went out of office, said that there were no funds out of which to pay a dividend. Directly they retired the call was made by the present directors, and a dividend was paid. Was that dividend paid out of the call?

The SOLICITOR, in reply, said that M. Philippart considered that the dividend was paid out of the money gained in connection with the shares he had forfeited.

Professor AYRTON, in answer to a question, said that no accumulator whatever that he had seen could compare electrically or commercially with the Faure-Sellon-Volckmar.

On the motion of Mr. STAPLES, the meeting was adjourned to the 15th October.

Mr. STAPLES made a few remarks expressing sympathy with M. Philippart on account of the trouble he had gone through, and hoping that he would get over his difficulty, and that he would see the Company, in which he was so largely interested, turn out a great success.

The proceedings then terminated.

COMPANIES' SHARE LIST.

TELEGRAPHS.

COMPANIES.	CLOSING PRICES JUNE 27.	BUSINESS DONE WEEK ENDING JUNE 27. Highest.	Lowest.
Anglo American	49½, 50	50	49
Do. Preferred	81½, 81¾	82	81
Do. Deferred	18¾, 19¼	19¼	18½
Brazil Submarine	11¾, 12	12	11 13-16
Cuba	10¼, 10¾	10⅝	10½
Do. Preference	17½, 18½	—	—
Direct Spanish	5½, 5¾	5½	—
Do. Preference	15½, 16	15¾	—
Direct United States Cable	12½, 12¾	12¾	12½
Eastern Telegraph	10¾, 10⅞	11	10 11-16
Do. 6 per Cent. Preference	13⅛, 13⅜	13 1-16	—
Do. 5 per Cent. Debentures, 1899	104, 107	104¾	—
Eastern Extension	11⅝, 11⅞	11 15-16	11 11-16
German Union	10, 10½	10⅛	—
Globe Telegraph and Trust Company	7 3-16, 7 5-16	7 5-16	7 3-16
Do. Preference	12⅞, 13	13 1-16	12 13-16
Great Northern	12⅞, 13⅛	13 1-16	—
Indo-European	31½, 32½	—	—
Mediterranean Extension	1½, 2	—	—
Do. Preference	5½, 6½	—	—
Reuter's	9½, 10	—	—
Submarine	247, 252	—	—
West India and Panama	1 1-16, 1 3-16	1⅛	1 1-16
Do. 1st Preference	6⅜, 6¾	6½	—
Western Brazilian	6½, 6¾	6¾	—
West. Union 7 per Cent. 1st Mortgage	122, 124	—	—
Do. 6 per Cent. Sterling Bonds	103, 106	—	—

TELEPHONES.

Consol. Telephone and Maintenance	¼, ½	½	—
Oriental	7-16, 9-16	½	7-16
United Telephone	9¾, 10¼	10 9-16	10 1-16

ELECTRIC LIGHT.

Anglo-American Brush Lgt. (£4 paid)	3½, 3¾	3 13-16	3½
Do. (fully paid)	7½	7⅛	—
Hammond Light	3½, 3¾	3 5-16	2 11-16
Swan	1⅜, 1⅝	—	—
Maxim-Weston	3-16, 5-16	—	—

MISCELLANEOUS.

Telegraph Construction	33¾, 34¼	34¼	33⅝
India Rubber, Gutta Percha, and Telegraph Works	30½, 31½	—	—

BOOKS RECEIVED.

A Treatise on Electricity and Magnetism. Vol. I. By Professors E. Mascart and J. Joubert. Translated by Professor E. Atkinson. London: De La Rue and Co.

Practical Electric Lighting. By A. Bromley Holmes, Assoc. M. Inst. C.E. London: E. and F. N. Spon.

Telephon, Mikrophon, und Radiophon. Von Theodor Schwartze. Wien Pest. Leipzig: A. Hartleben.

Die Elektrischen Mess-und Präcisions—Instrumente. Von Arthur Wilke. Wien. Pest. Leipzig: A. Hartleben.

Die Elektrolyse, Galvanoplastik und Reinmetall-Gewinnung. Von Eduard Japing. Wien. Pest Leipzig: A. Hartleben.

La Navigation Electrique, deuxième edition. Par Georges Dary. Paris: J. Baudry.

Secondary Batteries. By C. T. Kingzett, F.C.S. Reprinted from the *Journal of the Society of Chemical Industry*.

Vichy and its Therapeutical Resources. By Prosser James, M.D. Fifth edition. Baillière, Tindall, and Cox, and Alexander and Shepheard.

A Treatise on the Law of Electric Lighting, with the Acts of Parliament and Rules and Orders of the Board of Trade, a Model Provisional Order, and a Set of Forms. With an illustrated description of the principal apparatus used in electric lighting. By H. Cunynghame, Barrister-at-Law. Stevens and Sons.

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NOTES.

The Magazines.—In this month's *Nineteenth Century* Viscount Bury deals with "House Lighting by Electricity."

Brazilian Submarine Telegraph Company.—The traffic receipts of this company for the week ended 29th June, 1883, amounted to £2,458.

German Telegraphs.—Between the years 1878 and 1882 the number of cells at work in German telegraph offices was increased by about 20,000.

Competing Companies in America.—A Bill prohibiting the consolidation of competing telegraph companies passed the Pennsylvania House last week.

The Edison System in New York.—American papers say that Wallack's and the Madison Square Theatres in that city are to be lighted by the Edison system.

Direct Spanish Telegraph Company.—The estimated traffic receipts of this Spanish company for the month of June were £1,552, against £1,963 in the corresponding period of last year.

Cable Repaired.—The Western and Brazilian Telegraph Company notify the repair of their Maldouado Monte Video cable, thus restoring telegraphic communication throughout the whole of their system.

A New Telegraph Stamp.—A postage and inland revenue stamp of the value of 2s. 6d., available for postage, telegraph, and inland revenue purposes, is now being issued, and will shortly be obtainable from all postmasters, &c.

The Patents Bill.—According to the *Daily News* it was possible that the Patents Bill might be got through Grand Committee yesterday (Friday). Failing that, our contemporary regards it as certain that it will pass this stage on Monday.

Western and Brazilian Telegraph Company.—The traffic receipts of this company for the week ending 22nd June, 1883, were £1,793, after deducting the "fifth" of the gross receipts payable to the London Platino-Brazilian Telegraph Company.

Legal.—An American contemporary states that the Consolidated Electric Light Company, controlling the patents of William E. Sawyer and Albon Man, has brought a suit against the Edison Electric Light Company and others for infringement of patents.

West India and Panama Telegraph Company.—The estimated traffic receipts of this company for the half month ended June 30 were £2,478, as compared with £2,586 in the corresponding period of 1882. The February receipts, estimated at £6,742, realised £6,809.

An Electric Railway in Chicago.—Amongst the novelties at the Chicago Railway Exhibition is an electric railway, which is said to be largely patronised by visitors. On one day over 12,000 passengers are said to have been carried over the route in eight hours, without a hitch.

Electric Carbon, Storage, &c., Company.—We are informed that Messrs. Henry Bennett and Co., 131, Hope-street, Glasgow, have been appointed sole agents for the above company in Glasgow and district, and will in future undertake all business transactions there.

The Telephone in Belgium.—It is stated by a contemporary that an important Belgian paper, *La Flandre Liberale*, has a special telephonic service of its own between Ghent and Brussels. The instruments used are those of Mr. Van Rysselberghe, of the Brussels Observatory.

Government Telegrams.—A return has been issued showing that £33,995 was expended on telegrams by the Government in official communications with foreign countries in the financial year ending the 31st of March, 1881, and £25,043 in the year ending the 31st of March, 1882.

Catalogue.—Messrs. Davey, Paxman, and Co., of Colchester, who are well known as builders of engines for driving electric light machinery, have just published a new catalogue which is worthy of perusal. It contains capital illustrations of their different makes, with explanatory letterpress and price lists.

Mathematical Physics.—The University College of Auckland, New Zealand, is in want of a Professor of Mathematics and Mathematical Physics, and offers a salary of £700 per annum for the appointment. Applications should be made to Mr. W. Kennaway, at 7, Westminster-chambers, S.W., before the 31st inst.

Cuba Submarine Telegraph Company.—The number of messages passing over the lines of the Cuba Submarine Telegraph Company during the month of June was 3,120, estimated to produce £2,700, against 3,023 messages, producing £2,951 in the corresponding month of last year. The traffic receipts for the month of March, estimated at £4,500, realised £4,609.

The Electric Light in Bygone Days.—A correspondent writes:—"I read in the *Illustrated London News* for September 5, 1855, page 307, that the 'electric light has proved a failure in Deal, and resort is to be again had to gas.' Some particulars of this attempt before the introduction of dynamos would be interesting. Can you or your readers give any?"

London Hospitals and the Telephone.—An attempt is being made to organise a special system of telephonic communication between the great London hospitals and the private residences of their staff. If this very praiseworthy endeavour be successfully carried out, it may be the means of alleviating much suffering, and possibly of preventing many a death.

The Pilsen System.—We understand that the Pilsen Joel and General Electric Light Company are about to exhibit an installation of eight Pilsen arc lamps at the Cork Exhibition. We are also informed that the same company has just despatched an installation of 14 Pilsen arc lamps to Stockholm, which are intended for the lighting of one of the principal portions of that city.

Reducing Battery Expenses.—According to a recent report by Herr Kolb, secretary to the German Telegraph Administration, the expenses incurred during the course of the official year, 1881-82, in maintaining the 127,166 cells employed by that administration, amounted to £12,350. The Government recouped £2,727 of this amount, however, by the sale of copper crystals, zinc, lead, &c.

The Late Sir Edward Sabine.—The funeral of General Sir Edward Sabine took place on Saturday last at noon, at Tewin, near Hertford, where the family vault is situated. The body was brought by rail from London to Welwyn, and from thence was conveyed in an open crescent hearse to Tewin Churchyard. There was a large body of mourners, amongst whom were several members of the Royal Society.

Liverpool Junior Conservative Club.—The principal rooms of this club, which was opened on Tuesday, June 26, by Earl Lathom, have been fitted throughout with electric lights. Compound gas and electric fittings have been supplied by Messrs. Bennett Brothers, and the electrical part of

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the work has been carried out by the Liverpool Electric Supply Company, under the personal superintendence of Messrs. Holmes and Vaudrey, the company's engineers.

AN INCOMBUSTIBLE INSULATOR.—A patent has recently been taken out for an incombustible insulating material. The inventor combines paraffin and castor oil with india rubber, and then mixes the compound with oxychloride of zinc or lead. By combining the paraffin and oil with the rubber, he states that he is able to incorporate with them a greater proportion of the substances used for rendering them imflammable. The inventor's name is A. Parkes, and the number of the patent 5,388 for 1882.

SUN SPOTS AND TERRESTRIAL MAGNETISM.—A telegram to *The Times*, from its Philadelphia correspondent, dated July 2, says:—"Professor Brooks, of Redhouse Observatory, Phelps, New York, reports telescopic observation of an enormous group of spots now central on the sun's disc, visible to the naked eye, the diameter of the group being 50,000 miles. They exhibit violent cyclonic action, electrical storms and aurora accompanying the solar outbreak. A brilliant aurora was visible on the earth at the time of observation."

ANGLO-AMERICAN TELEGRAPH COMPANY.—At a meeting of the Board of Directors of the Anglo-American Telegraph Company, held on the 29th ult., it was resolved, after placing the quarterly sum of £37,500 to the renewal fund, to declare an interim dividend for the quarter ending 30th June, 1883, of 15s. per cent. on the ordinary stock, and 30s. per cent. on the preferred stock, both free of income-tax, payable on the 1st August to the stockholders registered on the books of the company on the 30th June, 1883.

THE EDISON SYSTEM IN LONDON.—On the occasion of the dinner given by the Speaker at his residence on Saturday evening last the riverside terrace was illuminated by Edison incandescent lamps. Seventy-eight 16-candle and three 100-candle lamps were employed, the current being furnished by the Edison plant in the House of Commons. The Prince and Princess of Wales, who were amongst the guests, expressed much approval of the lighting arrangements. The Adelaide Gallery, Strand (Messrs. Gatti's) is being wired for 325 Edison lamps.

MORE REDUCTIONS IN GAS BILLS.—The price of gas supplied by the Gas Light and Coke Company to the street lamps of the metropolis has recently been reduced to 2s. 10d. per 1,000 cubic feet; while common gas (16 candle illuminating power), supplied to private consumers, will be reduced to 3s. per 1,000 feet from 1st January next. Now, if there is one thing more certain than another, it is that the electric light has had nothing to do with this reduction, or rather that the gas journals will say so. Other folks may be of a different opinion, however.

ANOTHER NEW ACCUMULATOR.—Mr. James Shepherd, of 45, Via Stella, and 3, Piazza Scala, Milan, has resigned his position as general agent of the Italian Edison Company, and has taken out a patent for an accumulator, which he is now manufacturing on an extensive scale. We hope shortly to be able to furnish our readers with a description of this battery, with which, we are informed, good results have been obtained. Mr. Shepherd introduced both the Brush and Edison systems of electric lighting into Italy, and was the originator of the present Italian Edison Syndicate.

THE METAL TRADES EXHIBITION.—There are but few exhibits at the Agricultural Hall of a strictly electrical character, although many of the exhibits will be found interesting to electrical engineers. Messrs. Mather and Platt show a spherical engine with an Edison dynamo—at least we were informed at the private view that the engine was "on the road." Messrs. Felten and Guilleaume exhibit a fine assortment of wire and wire rope. The Leeds Forge Company have fitted up a marine boiler as a boudoir, and light the interior by means of incandescent lamps. The current for these lamps is supplied by a battery.

EASTERN TELEGRAPH COMPANY.—The directors are inviting subscriptions for £500,000 £4 per cent. Mortgage Debenture stock, issued under the authority of special resolutions of the company, according to which this stock constitutes a first charge on the undertaking and revenue of the company, and the total amount issuable is never to exceed one-third of the paid-up share capital of the company for the time being. The present issue is made for redemption of terminable debentures falling due in October next, and for payment for the Trieste-Corfu Telegraph cable and other important expenditures on capital account.

THE MAXIM LAMP IN AMERICA.—The *Electrical World* states that a contract between the Maxim Electric Light and Power Company, of Philadelphia, and the Lamp Committee of City Councils of Lancaster, Pa., has been signed. The Maxim Company agrees to have sixty lights in position and lighted by August 10th, and sixty additional lights by September 10th. The company filed a bond in the sum of 10,000dols. for the faithful performance of the contract. That number of lights costs the city 16,800 dols. per year. Our contemporary does not say whether the lights are to be employed in the streets, or a public building.

RUSSIAN FEMALE TELEGRAPHISTS.—An Odessa correspondent writes as follows:—"According to the semi-official *Journal de St. Petersbourg*, the question of the right of female telegraphists to the receipt of pensions has at last been favourably and definitely settled, thanks to the energetic efforts of Major-General Bezak, Director of the Department of Russian Telegraphs. The statute fixing these pensions has just been approved. The right of pension will be acquired after twenty years service. After twenty-five years the *télégraphistes* may retire on full pay. Marriage will entail no limitation of pension, but on the contrary the pension passes to the children."

A FRENCH SOCIETY OF ELECTRICIANS.—The articles of association of this society have been made public. The title will be "Société des Electriciens," and the head-quarters Paris. The objects of the society will be to form a centre for the collection of particulars as to the progress of electricity in all lands, to discuss electrical questions, to popularise and develop the applications of electricity by periodical publications, meetings, public experiments, &c.; to study industrial and economic questions, Government administration, and other matters affecting the distribution and employment of electricity, as well as the question of the extended use of natural forces. The members of the society will be divided into the following classes:—Honorary, subscribing, founders, and donors, the last three paying subscriptions in the shape of an annual sum, or a lump sum, as the case may be.

ELECTRIC LIGHTING AT WINCHESTER.—During the Royal Counties Agricultural Society's Show held this week, the New Guildhall was most efficiently illuminated by the Pilsen system. The interior of the large assembly room and the exterior of the hall, including the clock tower, at an elevation of 85ft., were the special parts illuminated. The success of the undertaking has induced the city authorities to authorise a plan and estimate to be prepared for lighting a certain area of the city by this system with the view of adopting it during the coming season. The ordinary Schuckert dynamo and

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the improved Pilsen lamps were used on the occasion referred to, and worked well. The motive power was supplied by a portable engine made by Messrs. Wallis and Stevens, of Basingstoke, which ran very evenly. The work was undertaken and carried out by Mr. R. Bayley for the city authorities.

THE ST. GEORGE TELEPHONE.—On Tuesday last a series of experiments were made in the presence of a number of gentlemen interested in the matter, with the St. George telephone, so named after its inventor, Mr. St. George, at No. 18, Telegraph-street, E.C. In this telephone a thin diaphragm of mahogany veneer is used in place of the ordinary metal one. The transmitter was placed in the stores of the St. George Telephone Company, South Arcade, Finsbury-pavement, E.C., about a quarter of a mile away, and the line resistance is said to have been equal to twenty miles of wire. Singing, the notes of a violin, and speaking were heard with distinctness, despite the fact that the overhead wires in this quarter of the City are multitudinous, and some induction effects might reasonably have been expected. The St. George receiver was described in these columns some months ago, and we hope to be able to give a description of the transmitter shortly.

THE PROVISIONAL ORDERS BILL.—In the House of Commons on Wednesday night, on the order for the second reading of the Electric Lighting Provisional Orders (No. 5) Bill, Sir H. Vivian asked whether any provision had been made for the representation of the district authorities in regard to this Bill, and whether it was intended by the Board of Trade to refer it to a select or a hybrid committee.—Mr. J. Holms said the electric light undertakings were of a novel character, and these were the first Provisional Orders on the subject which had come before the House. It was proposed to refer them to a hybrid committee, so that they might be fully considered; but the Government was very much in the hands of the House, and it was open to any one to make any other suggestion.—Mr. Stanhope said that unless the Bills were opposed it would not be of much use referring them to a committee, as the points of detail would not be properly brought out except by opposition. The Bill was then read a second time.

ELECTRIC LIGHTING FOR HOTELS.—An installation of three Pilsen arc and 28 Gatehouse incandescent lamps has just been completed at the Inns of Court Hotel, High Holborn. Two of the arc lamps are used for lighting up the central reading and smoking court, and one for the Holborn entrance to the hotel. The Gatehouse incandescent lamps, of 20 candle-power each, are used for lighting up the dining room on the Holborn side of the hotel. The current is obtained from dynamo machines driven by steam power at the central station of the Pilsen, Joel, and General Electric Light Company (Limited), in Whetstone Park, Holborn. The temperature and atmosphere of the dining room is found to be much more agreeable with the new class of light than when gas was used. We believe that this is one of the few cases in which arc lighting has been successfully adopted for reading and writing rooms, the well-known steadiness of the Pilsen lamp rendering it possible. The Hotel Company are to be congratulated upon this accession to the comfort of their visitors.

INCANDESCENT LAMPS.—A novel method of making this class of lamps has recently been patented by Messrs. Boulton, Soward, and Probert. They take a glass vessel of globular shape, having two platinum electrodes inserted therein at a suitable distance apart, and either solid or tubular. A carbonaceous gas is then introduced into the glass vessel. The outer ends of the electrodes are connected to an electric generator of high tension, and sparks caused to pass through the gas inside the globe, between the electrodes. In consequence of this the gas is decomposed, and a deposit of carbon takes place upon one of the electrodes, "which deposit," to quote the patentees, "is gradually built up by means of a rapid succession or continuous flow of sparks, and a bridge of carbon is thus formed, so that the space separating the said metallic electrodes between which the spark passes is completely arched over." This bridge forms the filament, and after exhausting the globe of air, the lamp is ready for use. The number of the patent is 5,373 for 1882, and it has just been published.

FUNERAL OF THE LATE MR. SPOTTISWOODE.—At noon on Thursday the remains of the late President of the Royal Society were laid in Westminster Abbey, the Dean of Westminster having acceded to the very numerously and influentially signed memorial asking that this honour might be paid to the mortal remains of one who so well deserved it. Amongst the pall bearers were Sir William Siemens, representing the British Association; Sir William Armstrong, the Institution of Civil Engineers; Dr. Evans, the Royal Society; the Duke of Northumberland, the Royal Institution; Mr. Childers, Her Majesty's Government; Mr. Andrew Cockerell, the Prince of Wales, and representatives of the other scientific societies. Mr. Spottiswoode is buried in the north of Poet's Corner. He is not the first of his name who has been deemed worthy of such a resting place, as one of his ancestors, Archbishop Spottiswoode, appears to have been buried in the Abbey many years ago. It is needless to say that electrical science was numerously and worthily represented at the graveside.

THE DISCOVERY OF ELECTRO-MAGNETISM.—In *Les Mondes* for the 30th ult., Dr. Tommasi quotes a passage from an article in an Italian journal of the 3rd August, 1802 (the *Ristretto dei Foglietti Universali*, published at Trent), according to which a certain councillor, Jean Dominique Romagnosi, caused a compass needle to be deflected by means of the current from a Volta pile. This discovery is generally ascribed to Oerstedt who did not make it until seventeen years later than Councillor Romagnosi. Dr. Tommasi asks, therefore:—(1) Must we attribute the merit of having been the first to observe the deflection of the magnetic needle by the action of the voltaic current to Oersted or to Romagnosi? (2) Had Oersted any knowledge of Romagnosi's experiment when he published his discovery in electro-magnetism? (3) Are there other *savants* who may have had a hand in this discovery? He leaves the answers to these questions to the consideration of the electricians who will shortly be assembled at Vienna, in the hope that some information may be elicited at the meetings to be held during the exhibition.

CHEAP TELEGRAMS.—In the House of Commons, on Monday last, Mr. Alderman Lawrence asked the Chancellor of the Exchequer whether the House would have an opportunity of discussing the various schemes for the introduction of cheap telegrams before the order was finally made by the Post Office.—The Chancellor of the Exchequer said the question could be discussed on the Estimates.—Mr. Alderman Lawrence gave notice that on the occasion of the introduction of the scheme of sixpenny telegrams he would move that it was not expedient, in order to reduce the minimum price to sixpence, to increase the present tariff for twenty words and upwards, as would be the case under the proposed scheme. He would also move that it was not expedient to

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charge for the number of words in the addresses either of the receivers or senders. He intended to move the following as an alternative scheme:—"That addresses be considered of the value of 2d., that eight words at ½d. each would be 4d., and that 2d. added to 4d. would be 6d." His proposition was this: Eight words, 6d.; twelve words, 8d.; sixteen words, 10d.; twenty words, 1s.; twenty-four words, 1s. 2d.; twenty-eight words, 1s. 4d.; and thirty words, 1s. 6d."

CHELSEA AND THE ELECTRIC LIGHTING ACT.—At a meeting of the Chelsea Vestry on Tuesday, a report was brought up by Mr. Charles Mossop, the chairman of the Electric Lighting Committee, from which it appeared that the Metropolitan Board of Works had presented a petition against the preamble of the provisional order for Chelsea granted by the Board of Trade to the Metropolitan Brush Company, which had been approved of by the vestry. He pointed out that the vestry was the local authority named in the Act, and that the main sewers and works vested in the Metropolitan Board were already amply protected by the order, and in other respects that the Board had no direct interest in the parish, and protested against the interference with the principles of local self-government at the eleventh hour, more especially as the vestry had so fully mastered the subject and agreed with the board of Trade. He further complained of the want of courtesy of the board in presenting a petition without communicating with the vestry, and apparently obstructing the operations of the Act in the metropolis. The vestry unanimously approved the report, and resolved to support the provisional order and to oppose the action of the Metropolitan Board of Works, and sealed a petition accordingly to the House of Commons. During the discussion it was much deplored that there should be a want of unanimity between the vestry and the board, and a possibility of the ratepayers being involved in a double and entirely unnecessary expense.

ELECTRIC EXHIBITION AT VIENNA.—THE THEATRE.—From Vienna we learn that the theatre, which is to occupy the whole of the south-east gallery of the exhibition building, is approaching completion. It is to be very handsomely decorated, and will be lighted throughout by the incandescent system of electric lighting. The latter work has been entrusted to Messrs. Ganz and Co., of Buda Pesth, and will be carried out by Messrs. Braun and Heider, of Vienna, their agents. Swan lamps of 20 c.-p. are to be used. Fifteen will light up the entrance hall and ticket offices, 90 will be employed in the *foyer*, 184 in the auditorium, 30 in the orchestra, 90 in the dressing rooms, and 1,260 on the stage. Many of these latter will only be used occasionally, to produce changes of colour in the light thrown on to the stage. The dynamo which will supply the current, and which has been specially constructed for the purpose, will be situate in the machine room, some 350 metres away, the current being carried to the theatre by an underground cable. Messrs. Piette and Krizik, the inventors of the Pilsen system of arc lighting, will light the theatre with their lamps, so as to alternate the arc with the incandescent system, and thus afford an opportunity of comparing the relative values of the two methods for this class of lighting. This firm intend to light the auditorium by from 3 to 5 arc lamps, the stage by 2, which will act as footlights, and 2 or 3 at either wing. The remaining portions of the theatre will, however, continue to be lighted by the incandescent lamps.

THE ROYAL SOCIETY OF EDINBURGH.—The fourteenth ordinary meeting of this society was held this week at the Royal Institution rooms; Mr. Robert Gray, vice-president, in the chair. Professor Crum Brown, for the Astronomer-Royal, Professor Piazzi Smyth, read a note on the little *b* group of lines in the solar spectrum. The paper set forth that a number of spectroscopists, founding upon the results of imperfect observation, had been asserting of late that in the sun's atmosphere all or the most ordinary elements were decomposed into simpler bodies, and that in terrestrial experiments they found an apparent coincidence between the lines of the spectra given by two such substances as iron and nickel. That line they held was not really due to either iron or nickel, but to the basic element, as they called it, which was common to both. Professor Smyth demurred from this view, and submitted that in one of the most celebrated instances which were assigned, more perfect spectroscopic power enabled them to show that these apparently coincident lines were not really so.—Professor C. G. Knott contributed a paper on superposed magnetism in iron and nickel, which was followed by notes on the maximum density of water and surface emissivity by Professor Tait.—A photograph of the arm of a boy which had been struck by lightning, forwarded by Mr. Milne Home, was submitted for inspection. Professor Tait called attention to a marking on or under the skin resembling the foliage of a young carrot or of a yew tree, and added that the matter was worth the consideration of anatomists and physiologists.

A GALLANT RESCUE.—We have received the following from a Valentia correspondent, and have pleasure in finding a place for it in our notes:—"At Valentia, Ireland, on the evening of the 26th June, a little boy, five or six years old, named Michael Cremin, son of the hotel proprietor, accidentally fell over the pierhead into the water. His brother, a little older than himself, raised an alarm, which was heard by some persons about 100 yards distant, amongst whom was Mr. Daniel Herbert, one of the staff of the Anglo-American Telegraph Company, who, after running to the scene of the accident, divested himself of coat and vest and plunged into the water in a rapid tidal way, brought the child up from the bottom, and swam ashore with him. The child was taken to his home, where he is progressing favourably. A similar gallant rescue occurred here about two years ago, when, whilst bathing off Beginnis Island, the eldest son of Mr. J. Graves, the superintendent of the Anglo-American Telegraph Company, was seized with the cramp and sank. A lad named James B. Smith, also one of the staff, seeing this from the shore, immediately swam out to where he last saw him, in a strong tide, and after searching under water for him found him, and being himself so much lighter than the other, seized the latter by the foot, and swimming with one hand, dragged him ashore, where, after some time, he succeeded (without other help being available) in restoring him to consciousness, and ultimately the two rowed home a mile or more in their punt. Such acts as these deserve to be recorded to the honour of the rescuers in a journal devoted to electrical and telegraphic science."

ELECTRIC LIGHTING OF THE LAW COURTS.—Messrs. R. E. Crompton and Co., engineers to the Swan United Electric Light Company, have now completed the whole of the arrangements for lighting these courts by electric lights. On the evening of Friday, the 29th ult., Mr. Shaw Lefevre, M.P., First Commissioner of Works, made a formal inspection of the lighting arrangements, and was shown over the courts by Mr. R. E. Crompton and Mr. Swan. Mr. W. H. Preece, F.R.S., and a large number of ladies and gentlemen were also present. The large hall, as we have before stated, is lighted

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by six Crompton arc lamps. There are 20 courts, each of which has from 20 to 24 Swan lamps, besides corridors, &c., which are lighted by the same means. To supply the necessary current six Crompton-Bürgin dynamos are placed in a temporary iron building outside the courts, and are driven by one of Marshall's engines. As these are not quite sufficient to feed the total number of lamps, however, 82 2 horse-power Faure-Sellon-Volckmar accumulators, made by the Electrical Power Storage Company, have been provided in the vaults under the courts. These are charged by day, and will supply enough current to light the remainder of the lamps, as well as affording a reserve which can be utilised in case of any temporary breakdown in one or other of the courts. It will be remembered that some parts of the very extensive buildings comprising the new Law Courts were lighted on the occasion of the opening ceremony, early in December last. Since then the work has been pushed on with all speed, and the result is the completion of one of the largest undertakings of this character that has been attempted. Those of our readers who care for fuller details of the arrangement of the machinery, &c., will find a plan of the engine room in our issue of the 9th December last; illustrations of the interior of the great hall, and some of the courts, showing the position of the lamps, in our issue of the 16th December; and diagrams of the switch-boards and connections, in our issue of the 23rd December. It only remains for us to congratulate the Swan United Company, and their engineers, Messrs. R. E. Crompton and Co., on the successful issue of their labours.

The Supply of Electricity by Local Authorities.—A paper on this subject was read by Mr. Killingworth Hedges, of Westminster, at the annual meeting of the Association of Municipal and Sanitary Engineers, which took place this year on the 28th, 29th, and 30th of last month at Oxford. Mr. Hedges commenced by pointing out the probable disadvantages of letting the supply of electricity slip out of the hands of the local authorities and become the property of a company who, though prevented by the Electric Lighting Act from becoming actual monopolisers in the sense that the gas and water companies now are, would probably act in a way which would entail many disadvantages on the consumers. The author recommends local authorities to obtain power to act as undertakers, but at present only to partially exercise this power by acquiring a site for the generating station and erecting a suitable building, furnished with steam or hydraulic engines. From this station electric mains would be laid throughout the district to be lighted, and would be of such a size that they could be handed over for a time to any company whose system was to be experimented on. The disadvantage attending a change of system on this plan would be comparatively small, as the streets would not be interfered with, and, in the event of the supply being inefficient, the provisions of the Act could be rigorously enforced. The author gave some useful rules and tables for proportioning the sizes of the mains, and proceeded to show the necessity of having some efficient means of automatically reducing the supply of each house in the event of the current increasing to an extent which would be dangerous. The necessity of a constant supply was pointed out, for which purpose the economy of using storage batteries as reservoirs of electricity already made up for the uncertain duration of their component parts, which, if unburdened with patents, could be replaced at prices little above the cost of ordinary lead. The meter system of charging for the supply was shown to be hardly developed at present, and the plan of maintaining a constant current during stated intervals would probably be more suitable to the immediate wants of the consumer, especially if the undertakers were to lay two or more service mains, which could be either used singly or coupled up, at the option of the consumer, by a simple apparatus, which would be verified by a system somewhat similar to the bell punch used by the tramway companies to check the receipts. The paper was followed by a discussion, in which Mr. Blakesley, C.E., M.A., and several members of the association took part.

Sixpenny Telegrams.—The following Treasury minute with regard to the reduction of the minimum charge for Post Office telegrams, dated June 14, 1883, has been issued as a parliamentary paper:—"The Chancellor of the Exchequer states to the Board that since the adoption by the House of Commons, on the 29th of March last, of a resolution that the time had arrived for reducing the minimum price of telegrams to 6d. he had carefully considered how and when the wish expressed by the House of Commons could be carried out. He reminds my lords that in his financial statement he said, 'After the resolution of the 29th of March, I do not think it would be respectful on my part to put out of question the reduction in the minimum price of telegrams. As I promised, I have already commenced a careful inquiry into the estimates made by the Post Office as to the cost under several plans of the reduction to the minimum charge of 6d. I cannot, at this moment, anticipate the results of that inquiry; but I propose to set aside £170,000 out of my balance to enable me, if possible, to carry out the change in the course of the present year.' Mr. Childers has since been in frequent communication with the Postmaster-General on the subject, and has ascertained that, if directions be now given to provide the additional plant, &c., expected to be required for the introduction of any rate, with 6d. as a minimum, the reduction could be made on the 1st October, 1884. Mr. Fawcett has satisfied him that it would be necessary first to expend about £500,000 in new main lines of telegraph and other works, of which as much as £200,000 might be brought in course of payment in the present financial year. The Chancellor of the Exchequer has also discussed with the Postmaster-General the probable loss which may be expected from the adoption of one or another of the tariffs suggested by Mr. Fawcett, with the following results: 1. Free addresses to be abolished, and ½d. charged for each word, including the address; minimum charge 6d. Estimated loss of income in first year of adoption, £170,000. 2. Address of receiver to be free, but that of sender to be charged for; 6d. to be charged for the first five words and 2d. additional for each subsequent five words. Estimated loss of income in first year £270,000. 3. Scale as in 2, but both addresses to be free. The loss would be larger than in 2, and the preliminary expense would be increased from £500,000 to £625,000. It appears to the Chancellor of the Exchequer that Scheme 3 involves too heavy a charge on the public; and without prejudging the question whether Scheme 1 or Scheme 2 should be adopted (a decision on which question may well be postponed for further inquiry), he recommends that general authority be given to the Postmaster-General for the necessary preliminary expenses, expected to amount to £500,000. It will, however, of course be necessary to obtain specific Treasury authority for each work in the usual manner. Mr. Childers is further prepared for an expenditure of £200,000 in the current year; and he recommends that the Postmaster-General be instructed to prepare a supplementary estimate not exceeding this amount for early presentation to the House of Commons in the usual manner. My Lords concur, and desire that a copy of this minute be sent to the Postmaster-General for his information and guidance."

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ELEMENTARY ELECTRICITY.—XIII.

(CONTINUED FROM PAGE 104.)

Electrical resistance, like all other physical quantities, must be measured in terms of a unit of its own kind. The unit generally adopted is called an ohm. It was originally determined by a committee appointed by the British Association for the Advancement of Science, and was based on certain theoretical principles, which will be explained under the head of Electro magnetism. For the present it is sufficient to know that the ohm is the resistance of a certain coil of wire, measured at a particular temperature. The electrical resistance of all metals increases as the temperature is raised, the increase in the case of pure metals being greater than in the case of alloys. The British Association committee constructed a number of standard "ohms," of different alloys, and marked upon them the temperatures at which they were correct, but, after the lapse of twenty years, it appeared that the resistances of these standards had somewhat changed, and they were not consistent with one another. In addition to this, it has been found that the original determination of the absolute unit was considerably in error, and the International Committee have recommended that the standard ohm should be the resistance of a column of pure mercury, one square millimetre in section, and of a length to be determined in accordance with the electro-magnetic principles above referred to. This length will be between 104 and 105 centimetres.

The specific resistances of conductors are most conveniently expressed in ohms per cubic centimetre. A table so constituted shows the resistance in ohms of a cube of the substance of one centimetre edge when the current flows from one face to the opposite face parallel to the edges of the cube.

Table of resistances in ohms per cubic centimetre.

Copper	·00000165
Silver	·00000165
Gold	·00000210
Aluminium	·00000215
Zinc	·00000569
Platinum	·00000916
Iron	·00000983
Tin	·00001336
Lead	·00001985
Antimony	·00003590
Mercury	·00009619
Bismuth	·00013265
German silver	·00002117

The resistance of conductors increases rapidly with the temperature. Most of the pure metals experience an increase of resistance of about ·3 per cent. for an increase in temperature of 1 deg. C., or about one part in 330. The resistance of mercury increases by only ·072 per cent. per degree centigrade, or one part in 1,390. The resistance of German silver increases by only ·044 per cent., or one part in 2,273, and that of platinum silver alloy by ·031 per cent., or one part in 3,226 for each degree centigrade. It is on account of their low temperature variation that these alloys have been selected as the materials for standard resistances; but it appears that their co-efficient of temperature variation depends very much upon their state of annealing, and is liable to change, as is also their resistance at any given temperature, by lapse of time, and thus an uncertainty is introduced when standard coils of these materials are employed. It is for this reason that it has been decided to aodpt a column of pure mercury as the standard ohm.

When the resistance of any substance is known in ohms per cubic centimetre (or per cubic inch) it is easy to calculate the resistance of a wire of any given length and section, since the resistance is proportional to the length, and inversely proportional to the sectional area of the conductor. For very rough purposes it is convenient to remember that the resistance of a mile of copper cable one square inch in section is a little more than $\frac{1}{25}$th of an ohm.

Resistance coils and coils of insulated wire are generally constructed of German silver or platinum silver alloy. The wire is first doubled (for a reason to be explained later on), and then wound upon a bobbin, the ends of the wire being connected to stout copper terminals. These coils are so adjusted as to represent any required multiple or submultiple of an ohm. They are usually arranged in resistance boxes, with a contrivance by which any coil can be immediately thrown into or out of circuit. The adjustment of these coils and the construction of resistance boxes will be described when we speak of electrical measurements. In the early resistance boxes constructed by Wheatstone the coils represented miles of telegraph wire, some single coils representing 50 miles of wire. The resistance corresponding to a one mile coil of Wheatstone's is about 12·7 ohms. The temperature at which they are "correct" should be marked on all resistance coils.

The methods of comparing the resistances of conductors will be described under electrical measurements. When the resistance of a given specimen of wire has been determined, its resistance per cubic centimetre may be found by calculation when its length and diameter are known. The length of the sample can be determined with sufficient accuracy by ordinary measuring instruments when the wire has been straightened. The diameter is best determined by weighing the sample in air and in water. The weight of water displaced gives the volume of the wire, and hence its sectional area can at once be found, its length being known. For example, the following results were obtained with a sample of hard phosphor bronze wire. The length of the wire was 617·25 centimetres. Its weight in air was 60·585 grammes, its weight in water 53·325 grammes. The weight of water displaced was therefore 7·26 grammes. At the temperature of the water one gramme measured about 1·001 cubic centimetres. Hence the volume of the wire was 7·267 cubic centimetres. Its sectional area was therefore $\frac{7{\cdot}267}{617{\cdot}25}$ square centimetres. Its resistance was ·379 ohm. Hence its resistance per cubic centimetre was

$$\frac{{\cdot}379 \times 7{\cdot}267}{617{\cdot}25 \times 617{\cdot}25} \text{ ohm, or } {\cdot}00000722 \text{ ohm,}$$

which is rather more than four times that of pure copper, the resistance of pure, hard-drawn copper being ·00000165 ohm per cubic centimetre.

The electromotive force between the extremities of a conductor is measured by the number of units of work done on a unit of electricity in passing from one end of the conductor to the other. It is, in fact, identical with the difference of potential between the ends. If we say that a current, C, is flowing in the conductor, we mean that C units of electricity pass across any section of the conductor in a second. Hence if an electromotive force, E, send a current, C, along the conductor, the work done in each second will be E C units.

Similarly, if E denote the electromotive force around a circuit, and C the current in the circuit, then E represents the number of units of work done upon the unit of electricity, as it goes completely round the circuit, and E C will represent the number of units of work done in a second.

The work done in driving the current round the circuit is derived from the battery, engine (and dynamo), or other source employed for the production of the current. Of this work some may be expended by the current in decomposing chemical compounds which may form a portion of the circuit (electrolysis), some may be employed in producing motion in magnets, or in other conductors, or in the conductor itself, as in the various forms of electric motors; some may be expended in producing currents in other conductors, as in the induction coil. But if no energy is expended in any such ways the E C units of work done by the electric forces during each second must be converted into heat within the conductor, and must be the mechanical equivalent of the heat so produced. This is the case in a metallic wire which is conveying a current, but is itself stationary, and not in the neighbourhood of any moving wires or magnets. Now, by Ohm's law, if R denote the resistance of the conductor, $E = C\,R$. Hence the amount of work converted into heat by the passage of a current C through a conductor (or con-

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ducting circuit) of resistance R is C^2R, and increases as the square of the current.

This theoretical conclusion was verified experimentally by Dr. Joule, and is known as Joule's law. If H denote the amount of heat developed in the wire per second, expressed in mechanical units, then Joule's law is expressed by the equation,

$$H = C^2R.$$

Thus the heat generated in a conductor depends only on its resistance and on the strength of the current flowing through it, and increases as the square of the current.

The heat generated per second may also be expressed in terms of the electromotive force between the extremities of the conductor, or, if the conductor form a closed circuit, the electromotive force round the circuit, and the resistance, thus:

$$H = \frac{E^2}{R}.$$

Hence, we have:

$$H = E\,C = C^2R = \frac{E^2}{R}.$$

The practical units of current (the ampere), and electromotive force (the volt) are such that the work done per second when a current of 1 ampere is sustained by an electromotive force of 1 volt is 10,000,000 ergs. Now, one horse-power is equivalent to 550 foot-pounds, or, about 7,458,000,000 ergs per second. Hence, if an electromotive force of 1 volt be employed to send a current of 1 ampere round a circuit, work will be done at the rate of $\frac{1}{745.8}$, or nearly $\frac{1}{746}$ horse-power. This rate of doing work is called a watt.

The absolute units of current and electromotive force are so related that 1 erg per second is done by the unit electromotive force upon the unit of current. The volt is equal to 100,000,000, or 10^8 absolute units of electromotive force, and the ampere to ·1 absolute unit of current. Hence the work done by a volt upon an ampere in one second is 10,000,000 ergs. The ohm is 1,000,000,000, or 10^9 absolute units of resistance, and is such that a volt is capable of maintaining a current of an ampere through an ohm.

If an electromotive force, E, be employed to send a current, C, the horse-power exerted will be $\frac{1}{746}$ E C.

Similarly, if a current of C amperes is made to pass through a conductor whose resistance is R ohms, the horse-power required to sustain it will be $\frac{1}{746}$ C^2 R.

For example, if a 20-candle lamp requires an electromotive force of 110 volts between its terminals, and allows a current of ·6 ampere to pass, the horse-power actually required to light the lamp will be $\frac{110 \times {\cdot}6}{746} = {\cdot}0885$, nearly.

Again, suppose the current for 20,000 lamps, each requiring ·6 ampere, is transmitted along a cable having a resistance of ·1 ohm, the horse-power wasted in sending the current through the cable will be $\frac{12000^2 \times {\cdot}1}{746} = 19303$, nearly. Hence, conductors of very much less resistance must be employed in conveying the current for so large a number of lamps, and hence the lamps should be very near to the dynamos, or else conductors of very great sectional area must be employed.

When insulated copper cables, about an inch in diameter, are employed for the transmission of currents, it is found that if the current much exceeds 1,750 amperes per square inch of section of the conductor, the heat generated will cause a rise of temperature sufficient to injure the insulating material. Hence, on no account should the currents employed in electric lighting be allowed to exceed 1,750 amperes per square inch of section of such cables. If the diameter of the cables is greater the heat cannot escape at a rate proportional to the sectional area, and the amount of current per square inch of section of the conductors must be reduced. Hence, it is not generally advisable to use conductors of very great diameter, but when a current of several thousand amperes has to be transmitted it is best to use several cables in which the conductors are about an inch in diameter.

But in most installations considerations of economy will assign a limit to the amount of current transmitted per square inch of section of the conductor, which will be reached long before the maximum of 1,750 amperes per square inch is obtained. This limit depends upon the cost of power (price of coal, &c.) in the neighbourhood. For a given current the larger the conductor the less will be the power wasted in the transmission of the current, but the greater will be the interest (and depreciation) on the cost of the conductor. If the dimensions of the conductor be increased a point will presently be attained when any further increase in the diameter of the conductor will involve a greater expense in interest, &c., than will be saved by economy in power. This determines the most economical dimensions of the conductor. The limit will be attained when the interest on the whole cost of the conductor is equal to the annual cost of the energy wasted by the production of heat in the conductor. Suppose, for example, that a cable costs £10,000. We may suppose that its depreciation is very slight, and may take £500 as the annual cost of the cable. Suppose the current is flowing for 1,500 hours in the year, and the cost of power is $\frac{1}{3}$d. per horse-power per hour. Then 6s. 8d. per hour (during which it is in use) is the cost of the cable, and this is equal to that of 240 horse-power. Hence, if the energy wasted in cable exceed 240 horse-power, it will be economical to use a larger cable at an increased capital outlay, but if the energy wasted in producing heat in the cable is less than 240 horse-power, it would have been economical to have laid down a smaller cable. If a cable with a conductor of one square inch in section has a resistance of $\frac{1}{25}$ ohm per mile, and costs £1,500 per mile, this gives a limit of about 1,000 amperes per square inch of section as the most economical current, whatever be the length of the conductor.

If the ordinary type of Swan lamp be employed, requiring 1·2 ampere per lamp, it follows that one square inch of sectional area of the conducting mains will be required for every 833 lamps in circuit, or about 650 lamps might be advantageously served by a conductor 1in. in diameter. If lamps requiring only ·6 ampere are employed, 1,300 lamps should be attached to a conductor 1in. in diameter. If power can be supplied at a cheaper rate than $\frac{1}{3}$d. per horse-power per hour, or if conductors cost more than we have assumed, the strength of the current per square inch of the conductor should be increased.

LIGHTING THE PAVILION AT BRIGHTON.

We have recently examined the electric light arrangements carried out by Mr. Magnus Volk, to light the Pavilion at Brighton. Among the many difficulties which an electrical engineer has to contend against in an installation of this kind is that arising from the specification not to interfere with the existing gas burners. The results, therefore, although they may be very good, are really not the best, because the very best method cannot be adopted. To ensure the best effect the work must be commenced *de novo*, and hence we are inclined to appreciate more highly the success which is obtained under difficulties.

The Pavilion at Brighton has a history. In its most modern phase it is the centre of all the public amusements at Brighton. Here are held the balls, the *soirées*, the *conversaziones*, the musical *réunions*, and the thousand and one gay gatherings of a lively seaside resort.

Few public buildings are well ventilated, and the Pavilion at Brighton is no exception to the rule; hence the heat generated by the numerous gas jets, in addition to the vitiation of the air therefrom, was an objectionable feature of the crowded gatherings in these rooms. The corporation decided to try how far the use of electricity would improve these matters, and the work was entrusted to their electrical engineer, Mr. Volk.

The preliminary experiments were successful, but suggested various alterations in the distribution of the light in the permanent arrangements. These are being carried out, and no

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doubt the installation will within a very short time be completed.

General Particulars.

The machinery consists of a 40 horse-power nominal Robey semi-fixed engine, fitted with Korting's injector, in addition to the feed pump. The ashpit is carried from under the firebox to a trap in the yard, so that the ashes can be removed without causing dust in the engine room. The power is all taken off one side of the engine by a 16in. belt, owing to the limited space at disposal. The engine makes a maximum of 82 revolutions per minute.

The current is generated by a Siemens alternate current dynamo for 500 Swan 20 candle-power lamps, arranged in multiple arc, with two in series, running at 600 revolutions per minute.

are inserted in every branch, and in some cases to every pair of lamps.

The lamps are disposed as follows:—

Room.	No. 20-candle Swan lamps.	Original No. gas burners.
Entrance hall	12	20
Corridor	46	74
Music room	104	216
North drawing room	40	40
Saloon	52	64
South drawing room	32	40
Banqueting room	150	140
	436	594

Total resistance of lamps 0·321 ohm.

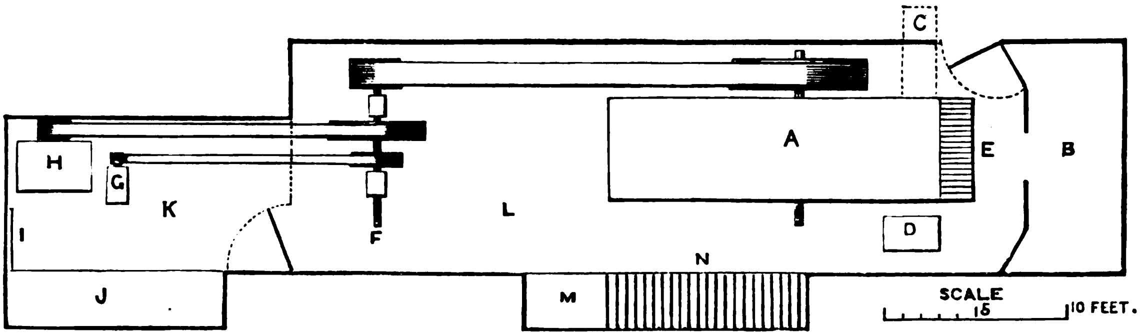

Fig. 1.—A, 40 h.-p. nominal semi-fixed Robey Engine. B, Coal Bunker. C, Sunk Ashpit, extending from under fire-box to trap in yard, for convenience in removing ashes. D, Sunk Water Tank. E, Grating, with Drain in bottom, to carry away water when "blowing off." F, Countershaft, &c. G, Exciting Dynamo, Siemens D^2. H, Alternating Current Dynamo, Siemens W O. I, Terminal Board. J, Bench. K, Dynamo Room. L, Engine Room. M, Cupboard. N, Air Grating.

The exciter used is a Siemens D_2. The former machine has an armature resistance = ·0137 ohm, with field magnets having a resistance of 3·8 ohms, the E.M.F. at the terminals being 94 volts. The field magnets are excited by a current of 25 amperes, the exciting machine having an armature resistance = ·3 ohm, and field magnets = 32 ohms.

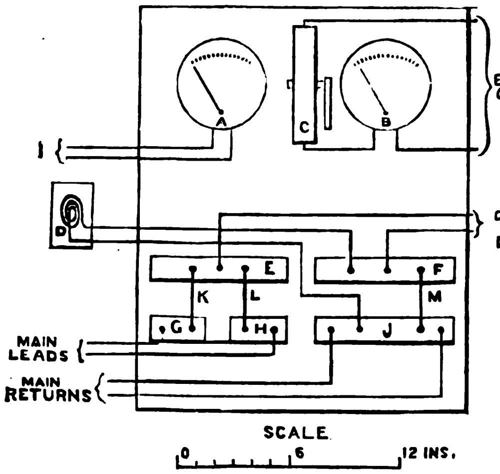

Fig. 2.—A, Volt Meter, the leads reaching to the point of distribution. B, Ampere Meter, for exciting current. C, Switch for exciting current. D, Siemens Dynamometer for main current. E, F, G, H, J, Terminal Plates. K, L, Lead Plugs. M, Short-circuit Plug for Dynamometer.

The main leads consist of four cables, each 280 yards long, two acting as one lead, each consisting of a stranded copper conductor, covered with two layers of gutta percha and a covering of tarred jute and tape. The approximate resistance of the main leads is ·044 ohm. The branch leads consist of a stranded copper conductor of 14 wires, each ·07 inch diameter, covered in the same manner as the main cables to a total thickness of 0·62 inch. The small branch leads on the chandeliers are covered with asbestos yarn, and fusible plugs

The rooms when lighted by gas required to have candles on the tables at banquets, and on the platform at concerts. The illumination is now so ample that candles are not required. The large number of lamps used in the banqueting room is owing to many having been added for decorative effect. The whole 500 lamps were originally put up, but were found to be in excess of the requirements. The reduced number also places the resistance of the leads to that of the lamps in a more favourable aspect, as owing to the comparatively short time the lamps are in use (about 500 hours per annum) it was not advisable to expend a greater sum on the main leads. The switches are arranged as follows:—Those for the music and drawing rooms are near their respective rooms, the centre and side chandeliers can be controlled separately, and raised or lowered by means of resistances. The switches for the rest of the building are in a case, with plate glass front, in the entrance hall.

The work has been one of considerable difficulty, owing to the peculiar decoration (Chinese) of the building, and the restrictions imposed by the authorities. The work has given the greatest satisfaction, and the estimate was only exceeded by five pounds.

ELECTRICAL RAILWAY SIGNALLING.

We take the following from our Parisian contemporary, *L'Electricien*:—

"We know the difficulty of making a good electrical contact when it is to be worked by a train running at a high speed, and that this contact is exposed to all kinds of atmospheric changes with scarcely any attention. It is to meet the requirements of a contact of this kind that M. L. Mors has invented the contact represented below, of which the principle and disposition are easily understood by reference to the description which accompanies the figure. It consists in utilising the vibrations produced by the passage of the train upon the rail to which it is fixed, to produce, by the movement of the mercury, a contact in a hermetically-closed space, which continues during the passage of the train. The contact works any apparatus whatever—bell, signal, disc, &c. Experiments

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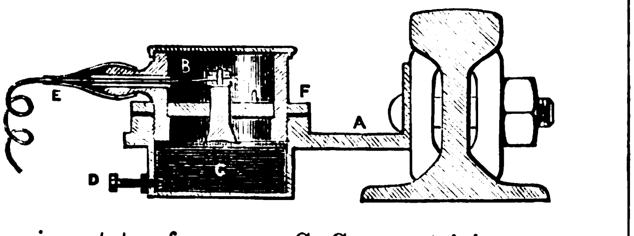
made upon the Paris-Lyons-Mediterranean line have given satisfactory results. The apparatus may be applied in any case where it is required that a mechanical vibration shall cause automatically a corresponding signal. A. Lever, bent at the end to be riveted to the fish plate. B. Contact cone, insulated from the iron box by a piece of ebonite or wood, upon which is a small plug, which is removed to replenish the mercury in the cup, if necessary. The large surface of the cone is about 2mm. from the surface of the



mercury in a state of repose. C. Cup containing mercury. This cup communicates with the rail by the lever, and forms the "earth" pole (copper or zinc, according to position). D. Small screw for regulating height of mercury, also for emptying the cup. E. Nipple, through which is forced the junction cable, covered with a thick india-rubber tube; upon this tube is placed another tube, which covers the nipple in such a manner as to form a hermetically closed joint. F. Iron cup containing mercury."

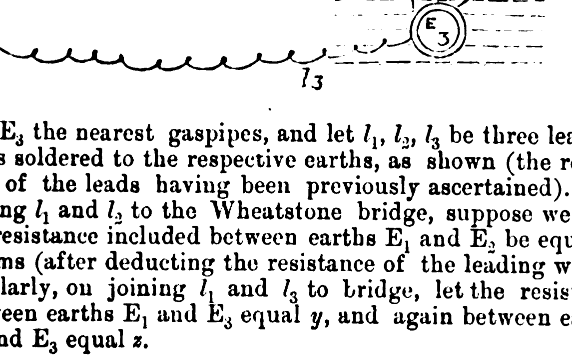
CORRESPONDENCE.

TESTING LIGHTNING CONDUCTORS.

TO THE EDITOR OF THE ELECTRICIAN.

Sir: In answer to "T. L. P.," I am sorry that, being out of town, I have not got my test book with me, but, as near as I can remember, I shall give him the results of one of my tests, after explaining what is meant by "*Absolute* resistance in ohms to earth of the lightning conductor."

In the diagram below let L C be the lightning conductor attached to earth E_1, whose absolute resistance to earth has to be determined, while E_2 and E_3 are two other earths, say E_2, the suction pipe of a pump communicating with a well,



and E_3 the nearest gaspipes, and let l_1, l_2, l_3 be three leading wires soldered to the respective earths, as shown (the resistance of the leads having been previously ascertained). On joining l_1 and l_2 to the Wheatstone bridge, suppose we find the resistance included between earths E_1 and E_2 be equal to x ohms (after deducting the resistance of the leading wires). Similarly, on joining l_1 and l_3 to bridge, let the resistance between earths E_1 and E_3 equal y, and again between earths E_2 and E_3 equal z.

Then (1) $E_1 + E_2 = x \ldots \therefore$ (4) ... $E_2 = x - E_1$.
(2) $E_1 + E_3 = y \ldots \therefore$ (5) ... $E_3 = y - E_1$.
(3) $E_2 + E_3 = z$.

Now substitute the values E_2 and E_3, as found by equations (4) and (5) in equation (3),

and we have $$x - E_1 + y - E_1 = z,$$
$$\therefore x + y - z = 2\,E_1;$$

or the absolute resistance to earth of

$$E_1 = \frac{x + y - z}{2}.$$

For example, I got something like the following: $x = 1{\cdot}1^{\omega}$, $y = 2{\cdot}3^{\omega}$, $z = 1{\cdot}8^{\omega}$ testing from the points of the lightning conductor.

Substituting these values in last equation

$$E_1 = \frac{x + y - z}{2} = \frac{1\cdot1 + 2\cdot3 - 1\cdot8}{2} = \cdot8 \text{ ohm}.$$

Therefore, the absolute resistance to earth of the lightning conductor through its earth, E_1 is only 0·8 of an ohm, instead of 1·1 ohm, as indicated by the first test or the resistance simply included between earths E_1 and E_2.

In this way I tested for the resistance of the earths used at several well-known cable stations, as well as the earths used on board telegraph steamers, and of two lightning conductors I put up at Malta about four years ago.

It is a very necessary and important matter either in the fitting up of a telegraph station or in the testing of a cable, to see that you have as perfect a low resistance an "earth" as possible. I well remember a case in the Levant, when, to all outward appearances, there was a good earth at an outlandish cable hut situated some little distance from the shore on dry ground which I used while localising a fault. Finding that my results threw the apparent position of the fault right away into the interior of the island opposite where the other end of the cable was landed, I had the apparently sound earth tested, and got over 50 ohms R. Upon unearthing the end of the cable for some distance, I found that a piece of newer cable had been added on to the original shore end to bring it up to the cable hut, and as the splice lay in dry, sandy ground, with little or no metallic contact between the sheathings, the true cause of the earth resistance was unearthed, and the splice properly made, when the earth gave less than one ohm, and the fault correctly localised.

In the case of lightning conductors, I think they should not be passed unless their absolute resistance to earth, including everything from the points downward, give under two ohms resistance in the dryest season. "J. L. P." has evidently got an excellent earth connection to his lightning conductor. The Government and municipalities should insist upon all public and prominent private buildings being tested periodically by some competent and trustworthy person.—Yours, &c., A. J.

Arran, June 26, 1883.

AN ARC LIGHT REGISTER.

TO THE EDITOR OF THE ELECTRICIAN.

Sir: The following simple device for automatically registering how an arc lamp has been burning during an evening having proved of such practical use at the Brighton Electric Lighting Station during the last six months, I think an account of it will interest some of your readers:—

The apparatus consists of three parts. A clock for rotating a piece of sensitised paper, a lens for throwing an image of the arc on this paper, and a screen to shut off all the direct light from the lamp, except that which passes through an angular opening.

Fig. 1 shows the apparatus complete. A is an ordinary American twenty-four hour clock, whose minute hand axis has been prolonged for about 2in. On this axis is fixed a light 12in. zinc disc, D; this carries the sensitised paper, which is held flat to it by a centre boss, B, with twelve equidistant radii made of thin brass wire, one being thicker than the rest to indicate the hour.

C is a triangular piece of zinc 10in. high and 3in. wide at

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the base. This carries a small 5in. focus lens behind an oblong aperture, N, ½in. wide, and a ¼in. in height.

F is a screen made of zinc, about 10in. square. H L is an

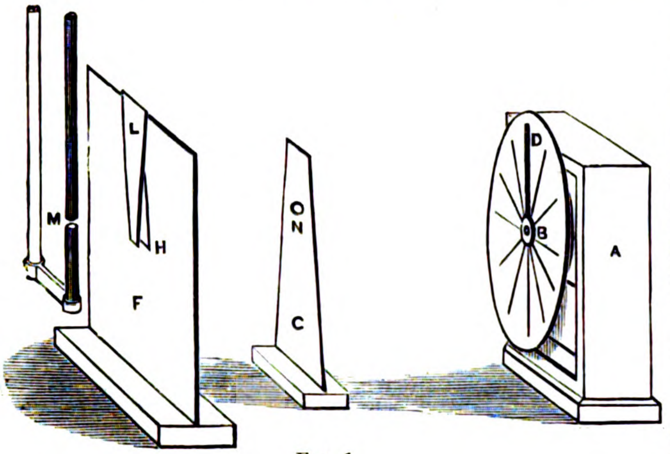

Fig. 1.

adjustable triangular opening, whose size can be varied by moving the piece L.

As the lower carbon burns down the image on D moves upwards. This causes the line to be traced in the form of a spiral, the distance between each turn being the length of the lower carbon burnt in an hour. The white lines left by the 12 brass wires divide the recording line into intervals of five minutes. This, along with the number of turns from the centre, enables us to know the exact time any particular feed took place.

The object of having the opening in F triangular is to regulate the amount of light passing through the lens, according as the image is projected at a greater or less distance from the centre of the registering paper, so that the resulting line traced shall have an equal intensity throughout, notwithstanding the paper moving more rapidly under the arc's image after the lamp has been several hours burning than it did at starting.

Thus it will be seen that the apparatus is perfectly automatic, requiring no further attention after the clock has been started and the image focussed; and it will register for more than eight hours if required.

Fig. 2 is a diagram taken by this instrument of a Brush lamp, and will show very clearly how every feed of the carbon, whether good or bad, is noted, as well as the time each feed took place.

The lens need not be halfway between the arc and the

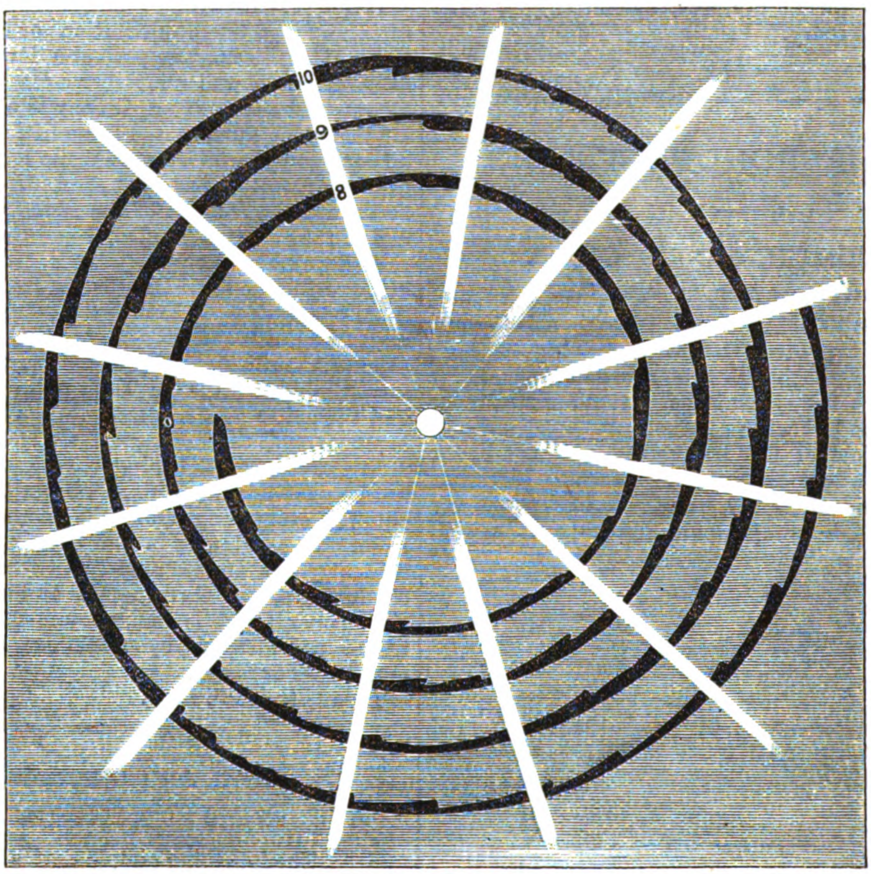

Fig. 2.

M is the arc lamp, a register of whose burning it is desired to take.

The lens stand C is placed 10 inches from the registering disc B, and an equal distance from the lamp M. F is placed about half way between M and C.

The height of the arc M is so adjusted that at starting its image on D is about an inch above the centre B, and the opening H L just allows the light to pass through the narrow upper part.

As the clock carries the sensitised paper forward under the image a line is traced the width of which exactly represents the length the arc had when that part of the paper was under the image, because the actinic power of the arc itself is so much greater than that of the white-hot carbon poles when taken horizontally that the latter have not time to imprint their images on the paper.

paper, so long as it is so placed that they occupy its conjugate foci. Fig. 2 was taken at a distance of seven inches from the lens, and therefore represents the burning of the lamp and the arc's length at about half their real amount.

For registering the burning of arc lamps in which both carbons feed, the lens would have to be slightly moved every hour, but in the majority of lamps now in present use only the positive carbon moves.

It will be obvious that a register thus taken must be far more reliable and useful than any statement of an observer, however careful he may be, besides being a great saver of labour and tedious watching, and if some such sort of registering were adopted at exhibitions or by manufacturers, the public would be far better able to judge of a lamp's steadiness than by merely seeing it burn for a few minutes. At Brighton, where there are between thirty and forty arc lamps

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burning every evening, a great many of which are placed outside shops, and exposed to all weathers, every lamp is cleaned once a month, and no lamp is sent out of the testing room until its burning has been registered, and has given a better diagram than such a one as Fig. 2.

When the register is finished the paper is dipped in a weak solution of hyposulphite of soda, in order to fix the image, and when dry numbered and dated for reference if necessary.—Yours &c, ARTHUR WRIGHT.

Brighton.

THE SYPHON RECORDER.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I desire through the medium of your valuable journal to call attention to a desideratum.

It is well known that since the publication of the *brochure* by Mr. J. C. Cuff in 1873 upon Sir William Thomson's "Syphon Recorder" nothing further, except a paper by Mr. James Alfred Ewing, published in 1876 by the Society of Telegraph Engineers, relating to the same subject has appeared in England.

The second pamphlet is admittedly a reprint of the first, with some few additions, embracing the latest improvements effected down to the date last mentioned.

Since the above dates, however, this beautiful instrument has undergone various modifications, both with respect to certain details of mechanism and its connections, which render the instructions of the above-named gentlemen less applicable. Indeed, the diagrams and plan of connections exhibited by them do not now correspond in many particulars with the present form of the instrument.

A French production has recently appeared by Mr. A. L. Ternant, which enters pretty fully into the latest developments of the above apparatus; but as many students, and more especially telegraphists, engaged in its manipulation are not acquainted with this language, they cannot avail themselves of the benefit of his manual, which, by all accounts, gives a lucid exposition of the principles governing the action of the instrument, and a clear explanation of its altered mechanism and connections.

Now, considering how extensively this instrument has been adopted, and the great favour with which it is received, I cannot help thinking that the want I have referred to should be supplied, and in order that it may speedily be met I have ventured to direct attention to the absence of a much-needed text-book.—Yours, &c., W. B.

Zante, 21st June, 1883.

GRAMME RING AND FIXING LINES OF FORCE.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Mr. W. B. Sayers has, I fear, misread my remarks on the above subject. What I said was that the product of E.M.F. and current (watts) in the external circuit was 100 per cent. greater with four poles than with two.

Mr. Sayers will see, therefore, that there is no necessity for me to explain how I got "1 per cent. of the normal E.M.F. when using one pair of magnets."

I need only add that when exciting one pair of field-magnets the other pair was removed.

As a supplement to the mode of fixing iron filings, showing the magnetic lines of force, described on page 98, perhaps the following method which I have found very easy and useful, may be of interest to some of your readers:—Fix a sheet of cardboard on a light wooden frame, and give it several coats of gum, allowing each to dry before applying the next. A good smooth surface is thus obtained. Place the card over the magnet and sprinkle the filings, tapping the card as usual to assist arrangement. As many of the filings will be vertical the card should be carefully lifted from the magnet, or if an electro-magnet be the subject of experiment, the exciting current may be stopped. Now gently direct a jet of steam on to the gummed surface, or subject it to a shower from a "spray producer." The gum being thus well moistened the filings sink in and are fixed. In lieu of a more orthodox arrangement a kettle with 3ft. or 4ft. of india rubber tubing will supply steam. Care should be taken to prevent the water which condenses in the tube from dropping on the card. This method is very useful when it is required to fix the curves over large magnets. Another way, not of fixing, but of printing the curves is to arrange them on a sheet of glass, and then gently place over them a sheet of paper moistened with gum and a solution of nutgalls, or starch paste and potassic iodide may be used. Very careful manipulation is required to obtain good results with this plan.—Yours, &c.,

July 2. W. M. MORDEY.

MEDICAL ELECTRICITY.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: My attention has just been called to the correspondence in your columns headed "Information Wanted, Medical Electricity." In my capacity as a public lecturer upon electrical subjects in numerous towns of England and Scotland I have been so often questioned upon this subject that I have latterly made it my business not only to gain all possible information about it from books, but also to commence a series of experimental investigations into the electrical resistance of various parts of the body, the most useful form of medico-electrical apparatus, the difference between the physiological effects of the continuous and the interrupted currents, and many other points. These experiments are still in progress, but Messrs. Sprague and Bennett, as well as others of your readers, may be interested to know that, at the request of the editor of *Health*, I am writing for that journal a series of articles upon the subject of medico-electric appliances, which will very shortly be commenced therein, and will be continued weekly. One object that I have in view is to expose some of the quack and sham appliances by which an ignorant public is being deluded.—Yours, &c.,

WM. LANT CARPENTER.

36, Craven-park, Harlesden, N.W., July 2.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Will you allow me to make a remark anent the letter of your correspondent, Mr. Sprague, page 159. Whilst rightly conceding to electricity curative virtues, and to magnetism little or none, Mr. Sprague regrets that "medical electricity has been too much left in the hands of a few medical specialists, and that no reliable scientific information can be gained."

I would call his attention to the following list of splendid works on medical electricity, published in England and abroad, wherein he will find much information on the subject, and learn that medical electricity has long since held an important and honourable position.—Yours, &c.,

194, Regent-street, W. J. L. PULVERMACHER.
July 2, 1883.

Dr. Golding Bird. Guy's Hospital Reports, p. 107.
Dr. Heidenreich. Elements of Therapeutic Physics, p. 248. 1854.
Dr. T. Pereira, F.R.S., &c. Materia Medica, p. 53, ed. IV. 1854.
Dr. Duchenne. Local Electrisation, p. 39. 1855.
Count Du Moncel. Application of Electricity, pp. 237 and 239, II. 1853.
Dr. Becquerel. Electricity, its Application in Medical Treatment, p. 36. 1857.
Dr. O. Kowalewski. Electricity and Medical Treatment, Vol. I., p. 12. 1857.
Professor De la Rive. Treatise on Electricity in Theory and Practice, Vol. III., p. 604 to 609, ed. I. 1853.
Dr. Tripier. Manuel d'Electrothérapie, p. 84, ed. I. 1861.
Dr. Garratt, of Boston. Electro-Physiology and Electro-Therapeutics, p. 117. 1861.
Dr. C. B. Radcliffe, M.D. Epileptic and Convulsive Affections, p. 180, ed. III. 1861.
Dr. Garratt. Medical Use of Electricity, p. 117, ed. II. 1861.
Dr. Desparquets. L'Electricité appliqué au Traitement des Maladies. 1862.
Dr. Wunderlich. Pathology and Therapeutics, Vol. I., p. 113. 1863.
The Gazette des Hopitaux, Paris, 27th July. 1852.
Drs. Hamilton and Allan. Clinical Electro-Therapeutics. 1873.
Drs. Beard and Rockwell. Medical Surgical Electricity, p. 13, ed. I. 1871.
Dr. G. V. Poore. Electricity in Medicine and Surgery, p. 5. 1876.

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THE ELECTRICIAN.

TO CORRESPONDENTS.

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THE INVENTION OF THE ELECTRIC TELEGRAPH.

It is always an invidious task, and sometimes a painful one, to have to weigh the claims of competing inventors. In deciding or discussing questions of this sort the most amiable qualities are often a snare to the arbitrator. He wants to be generous, he is anxious to redress a wrong, and in his haste he is apt to be over kind at somebody else's expense. This is especially the case where an invention which has established itself as a practical working system is afterwards found to have been foreshadowed or forestalled by some one whose efforts did not meet with like acceptance and a similar reward. To award honour where honour is due—a phrase we have heard a good deal of lately—is a very easy process, providing, first, we know where it is due, and, secondly—what is after all the main point—are quite sure as to the kind of honour we wish to award. Quite recently a discussion of this sort, not yet ended, has occupied the attention of people interested in the telephone; and now a still more exciting topic for disputation has been furnished in the interesting papers unearthed by Mr. Fahie relating to the invention of the electric telegraph.

The first instalment of Mr. Fahie's contribution on this topic will be found in another part of our present issue, and we are sure it will attract the notice its importance entitles it to. Our readers will peruse it with interest, and possibly with some of the enthusiasm manifested by the editor of the documents, an enthusiasm which will experience no abatement when the concluding portion of his communication, which we are compelled to hold over for another week, comes to be published. On the whole we would prefer to leave the question of priority, or honour, or whatever else it may be called, to the judgment of a discriminating public, at all events until the facts on the other side, if there are any, shall be made known. Some of our subscribers whose names have been associated with the electric telegraph from the very first may be able to throw some fresh light on the subject so far as it is a disputable one, and we shall gladly endeavour to afford space for any material contribution to the general stock of facts. All that we venture to deprecate is that spirit of partisanship which questions of this kind are so liable to develop. We may fully recognise and appreciate the value of one set of inventions without in the least forgetting our indebtedness to a set of another kind.

Our indebtedness has hitherto been thought to be due to Messrs. Cooke and Wheatstone. Their telegraph is a fact, and we Englishmen have as a rule ungrudgingly awarded them the distinction of being the first to establish the practicability of electrical signalling, without inquiring too nicely as to whether the ideas they contrived to work out were exclusively their own. Now and again we have heard it hinted that they got more credit than they were actually entitled to; but this, as we have observed in our opening remarks, depends upon the sort of credit we are disputing about. Probably Messrs. Cooke and Wheatstone's title to fame will not be much disturbed by these revelations concerning Mr. Davy, their contemporary and rival, for the insufficient but still practically effectual reason, that Mr. Davy's telegraph has not survived, whereas that of his competitors has. If the law of survival holds good in the world of invention as it does in the animal kingdom, then the telegraph we are now using is the fittest, and that which we have not used was less fit. On the other hand, several of his ideas have survived, or perhaps we should say have re-appeared, in very tangible shape since his time, though the man who gave birth to them fell out of the race.

To this extent Mr. Davy himself, who, we are glad to hear, is still living, and his champion, Mr. Fahie, would probably go with us. But the MSS. evidence now published relating to Edward Davy's early experiments goes farther than this, and outside it. These manuscripts, the authenticity of which is beyond all question, tend to show that the obscure occupant of 390, Strand, London, was not only an ingenious inventor, but a clear-headed and far-seeing man. Of his peculiar, and even wonderful, grasp of the properties of electricity there can be no question. One cannot help feeling as we read the highly suggestive notes and confident anticipations with which his memoranda and letters are crowded, that, had he remained in England to steer the destinies of the electric telegraph, it would have made more progress than in other hands it actually did make. What he accomplished was clearly the outcome of his own original mind; and what he predicted as possible, but allowed to be fulfilled by somebody else, belongs to him also. Whether anybody borrowed from him afterwards is another matter. All the circumstances considered, however, and looking back on the history of inventions generally, we, for our part, should say it would be extremely surprising if more than one person did not owe him much that has never been acknowledged. The early history of inventions, like the early history of nations, is very good fiction in its way; but the autobiography of in-

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ventors would be far more edifying, and certainly more amusing.

In the slight autobiographical sketch put on record some forty-five years ago by Mr. Davy there is very little reticence and no want of candour—virtues not over common amongst the class of persons to which he belonged. It is evident, however, that he lacked virtues, one of which the inventor should never be without, namely, either money or business capacity. He appears to have exhibited his inventions before he patented them; and he lets us see plainly enough that he half suspected some of his visitors of trying to appropriate his invention, though he neglected the ordinary precautions against their doing so. It is satisfactory to know that he did get some slight return by his exhibition, though undoubtedly an inadequate one for his labours, but he failed to receive that reward which men of Mr. Davy's temperament value far more than hard cash, namely, public acknowledgment. That some meed of this much-prized award may now fall to his lot every candid reader of Mr. Davy's MSS. will sincerely hope; and on this account alone, if for no other, Mr. Fahie's historical notes will be heartily welcomed.

HONOUR TO WHOM HONOUR IS DUE!

EDWARD DAVY AND THE ELECTRIC TELEGRAPH, 1836 TO 1839.

BY J. J. FAHIE, MEMB. SOC. TEL.-ENGS. AND ELECS.

Few of our readers have heard of the name of Edward Davy in connection with the history of the telegraph, and for the sufficient reason that, beyond a few very short and very imperfect accounts* of a needle telegraph which he exhibited in London in 1837-38, and the patent for an electro-chemical recording telegraph, secured in July, 1838, nothing has been published regarding him and his early labours. Yet it is certain that, in those days, he had a clearer grasp of the requirements and capabilities of an electric telegraph than, probably, Cooke and Wheatstone themselves; and had he been taken up by capitalists, and his ideas licked into shape by actual practice, as they and theirs were, he would have successfully competed with them for a share of the profits and honours, which have so largely accrued to them as the practical introducers of the electric telegraph.

This, at all events, is the conclusion that we have come to, after the perusal of a number of most interesting MS. documents, which have been obligingly placed in our hands by Dr. Henry Davy, of Exeter, Edward Davy's nephew; and it is a conclusion which, we believe, our readers will cordially endorse when they have read the extracts from them, which we are now about to give. We feel a peculiar satisfaction at being thus the means of re-introducing to his countrymen one who deserves a most honourable recognition. Mr. Davy, we are glad to say, is alive and well, and, though now 77 years of age, is still following his profession, as a surgeon, in a far-off colony, whither, for reasons which need not concern us, he emigrated in 1839.

The idea of an electric telegraph first occurred to him about 1836, when he sketched out a plan to be worked by static, or frictional, electricity. We give it almost in the author's own words:—

Outline of a New Plan of Telegraphic Communication, by which Intelligence may be Conveyed, with Precision, to Unlimited Distances, in an Instant of Time, Independent of Fog or Darkness.

The agent is electricity, which is well known to pass through a conducting medium with the rapidity of lightning. The only difficulty is in the mode of applying it to the end proposed. Our method is as follows:

Let us suppose a number of copper wires, each covered with silk, and varnished, to be laid underground, side by side, from London to Liverpool. For greater protection, they may be enclosed in an iron pipe. If there be a small brass ball at each end of each wire, an electric spark applied to the ball at the London end of any of them might be drawn at the same instant from the corresponding ball at the Liverpool end.

If there be twenty-four such wires, there will be one for each letter in the alphabet; but six wires would be more than sufficient in practice, owing to the numerous changes that might be made upon them by combination. We will, however, suppose that there are twenty-four, for the sake of illustration, and that the intelligence is to be sent from London to Liverpool.

The questions, then, are—

1st. How the wires are to receive the signals in London.

2nd. How they are to deliver them in Liverpool.

A single letter may be indicated at a time, each letter being taken down by the attendant as it arrives, so as to form words and sentences; but it will be easy to see that, from the infinite changes upon a number of letters, a great number of ordinary communications [whole sentences] may be conveyed by a single previously concerted signal [consisting of one, or more, letters in a group].

Let *a*, *b*, represent one of the wires—*a*, the London end, and *b*, the Liverpool end. At *a*, is fixed a small metallic cup of mercury; *c*, *d*, *e*, is a bar of metal moving on a hinge at *d*, so that when the end *c*, is elevated, *e*, will dip into the mercury; *f*, is a chain, or wire, communicating with the prime conductor of an electrical machine, or with a powerful electroforus. The hinge, or pivot, *d*, may be continuous metal, and common to all the bars belonging to all the wires

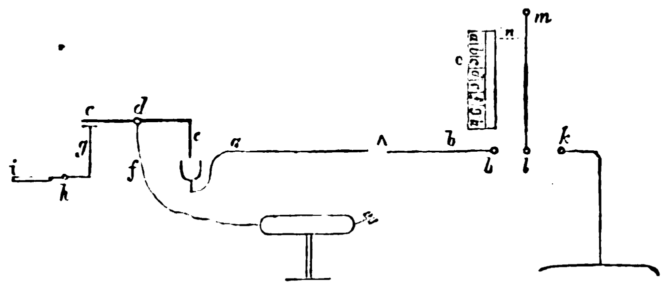

Fig. 1.

g, *h*, *i*, is made of glass, or partly of sealing wax, and turns on a hinge, or pivot, *h*, something like the key of a pianoforte. The pressure of the finger at *i*, will then raise *g*, and *c*, and depress *e*, which by dipping into the mercury will communicate the electric spark from *f*, to the wire *a*, *b*. This wire may stand for the letter *a*, and each of the others will be connected to a similar key apparatus, the same source of electricity sufficing for all.

At the Liverpool end is a small brass ball *b*, and *k*, is another, communicating by means of a metallic conductor with the earth; *l*, is a light [pith] ball suspended from *m*, by a rigid rod. When the electricity arrives at *b*, it attracts *l*, and immediately after repels it to *k*, where it discharges itself, afterwards resuming its normal position midway between *b*, and *k*. *o*, contains the letters ranged in a row, and each letter is connected to the rod of the corresponding electrometer by a stiff hair, as shown in the dotted line *n*. It is evident, then, that, at every movement of the rod towards *k*, the letter will be drawn from its place of concealment, and exposed to view in the open space above.

This, as Davy himself distinctly says, was not the plan that he would recommend in practice, and was described merely as an aid to a clearer perception of the principles involved. Accordingly, we find him, very soon afterwards, drawing up a proposal for a telegraph, based on the electro-magnetic properties of the Voltaic current.

This was to consist of as many line wires as there were

* *Mechanics' Magazine*, for January 20, and February 3, and 17, 1838; on which are based the very meagre and, of course, incorrect descriptions in all books on the telegraph. *The Penny Mechanic*, for February 10, 1838, and the *Morning Chronicle*, for January 25, and February 9, 1838.

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letters of the alphabet. Twenty, he says, would have sufficed, or a still fewer number would do, by having recourse to the various combinations of which they would be, obviously, susceptible. Besides the letter wires, there was to be one for the alarum, and another for the return circuit, which was to be common to all. As to the *form* of the wires Davy says:—"Since the electricity is believed to move on the surface, and not in the substance, of a conductor, I conceive that where there is a long distance to travel, instead of wires, it will be preferable to use broad ribbons, such as would be obtained by passing a thick copper wire between the rollers of a flatting mill." *

Each ribbon, for its perfect insulation and protection, was to be varnished with shellac, then covered with silk or woollen, and laid in a slight frame of wood, well dried and varnished; or each ribbon might be bound from end to end with listing, saturated with melted pitch, or surrounded with caoutchouc, or with cloth saturated with this substance. All the ribbons, in whatever way insulated, were to be laid together underground in air-tight and water-tight pipes of iron or earthenware.

The best source of electricity Davy considered would be, either one of Daniell's constant-current cells, then just discovered, or, perhaps, a magneto-electric machine as constructed by Newman, or Clarke. The electricity so obtained was to be set in motion in any of the required wires by a set of keys, resembling those of a pianoforte, and connected to their respective wires in the way that we have just described. On pressing a key, its wire would dip into a cup of mercury connected with the source of, say, positive electricity, and thus a communication could be readily established, which would be instantly broken when the finger ceased to press on the key. The return wire was to be permanently connected to the source of negative electricity.

At the receiving end the signals might be indicated in various ways, in the adoption of one or other of which much, he says, would depend on the actual amount of electricity that would be available. Davy gave the preference to the following method:—Each line wire was to terminate in another of smaller size, formed into a rectangular coil of from five to two hundred turns, according to circumstances. All the coils were to be ranged in a row in the magnetic meridian, and in each was to be suspended a delicate magnetic needle. The whole was then to be covered by a board, the straight edge of which just concealed the needles in their positions of rest, but, on any of them being deflected, allowed one end to project, and so expose the letter marked upon it. The feeblest current, says Davy, would usually suffice to cause this deflection; but if, *from the great distance that the electricity had to travel, it became too feeble, its effect on the needles could be increased by multiplying the convolutions of the coils.*†

"The quantity of electricity," he goes on to say, "requisite to deflect a magnetic needle is so inconsiderable, that if the current of a moderately-sized pair of plates were sent into one end of a wire, and only one-hundreth part of it came out at the other end, it would still be sufficient. It is for this reason that I prefer the method just described, of indicating the signals, to others which occur to me, and which, as they may answer under certain circumstances, I will briefly describe:—

"1. A coil of wire from each conductor may be wound round a vertical glass tube, a light needle, or slip, of iron inserted in this tube will be lifted up while the electricity is passing through the coil, a letter fixed to the iron by a bristle will then appear above the lip of the tube, and be the signal. The only objection to this plan, in other respects the neatest and simplest, is, that the force of the current after passing a long distance may not be sufficient to raise the iron.‡

"2. On the same principle, a piece of soft iron may be surrounded by a helix of copper wire, so as to form a temporary magnet, which will attract and relinquish a small piece of iron carrying the signal letter at every make and break of the current.*

"3. Instead of steel needles, coils of copper wire may be deflected in the neighbourhood of fixed magnets, thus, *a*, *b*, are mercury cups, into which dip the line wires *c*, *d*, and the ends of the coil *e*, which are provided with steel points, and rest

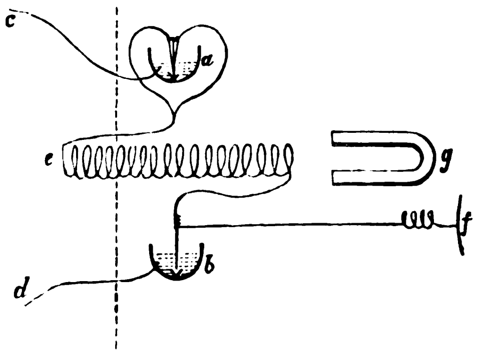

Fig. 2.

on agate surfaces, so that the coil can revolve with perfect freedom, a slender spring *f*, keeps the coil in its normal position of rest. During the passage of electricity in the coil it (the coil) will be subject to the influence of *g*, and be deflected."†

The alarum was to consist of a coil and needle, similar to those used for the letters, only that the needle was to carry a little fulminating silver card, which, on the passage of a current through the coil, was brought into the flame of a small lamp and exploded.

Davy concludes the document from which we have been quoting with a few words on the general question of conservancy, in which he says that the best situation for the lines would be along railways, where a number of men are constantly watching, and would prevent damage.

At short intervals, as every half mile, more or less, he would have a contrivance (not described), for ascertaining in what precise spot a fault existed, in case of any derangement of the wires. For this purpose the continuity of the copper was to be interrupted, and the two ends made to communicate by means of a cup of mercury. The places where these interruptions occurred were to be under lock and key in the possession of the surveyor.

According to the "Statement" which we find amongst Davy's MSS., giving the order in which his discoveries were made, he had not long finished the preceding paper when he saw how the number of wires might be reduced one half, by employing reverse currents to produce right and left deflections of each needle, each of which deflections could represent a letter. Other and very important improvements followed in quick succession, until, at the commencement of 1837, his ideas had not only assumed a really practical form, but his apparatus was so far complete that he was able to submit it to the test of actual experiment. For this purpose he obtained permission of the Commissioners of Woods and Forests to lay down a mile of copper wire, around the inner circle of the Regent's Park, through which, with the help of his friend, Mr. Grave, he performed many successful experiments.

Soon after this, in March, 1837, Davy appears to have been alarmed by the rumours which got abroad of Professor Wheatstone being engaged on an electric telegraph, and, in order to secure for himself a priority, he hastened to lodge a *caveat*, and, at the same time, deposited with Mr. Aikin, the Secretary of the Society of Arts, a sealed description of his invention, in its then state.

Davy now added the relay, or, as he called it, the "Electrical Renewer," which was the only thing wanted to make his telegraph complete and practicable, and the idea of which,

* It is but fair to mention that this and one or two others are the only cases of false reasoning to be found in all Davy's MSS.

† Cooke and Wheatstone, and Morse blundered painfully into a knowledge of this fact, of which Davy had thus early, 1836, so clear a perception.

‡ Here we have the axial magnet used in Royal House's Telegraph.

* Here we have the germ of the Morse Telegraph.

† Here we have the germ of the Brown and Allan relay. Davy says this plan is suggested on the possibility of steel magnets being influenced by the wrong wires, which might happen when all are close together in one parallel row.

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it appears, occurred to him after a conversation on the subject of a telegraph, with a Mr. Bush of the Great Western Railway.

In May, 1837, Cooke and Wheatstone applied for their first patent, and to this Davy entered an opposition, lodging with the Solicitor-General, of the time, a full description of his own apparatus.* A copy of this important document is now before us, and as, when taken in connection with what we have already given, it shows, in a very clear way, Davy's position in May, 1837, we shall copy it *in extenso*, merely omitting a few preparatory remarks on the general principles of an electric telegraph, which, though necessary, because little understood, in Davy's time, need not now be repeated. We have also made a few verbal alterations here and there, which, while they in no way affect the sense,† will, we hope, render the writer's meaning more clear. A comparison of this paper with Cooke and Wheatstone's first specification will be a curious study, and, all things considered, will certainly not be to Davy's disadvantage.

Outline Description of my Improved Electrical Telegraph.

The parts of the telegraph may be divided into three, viz.:

1st. Signal and alarum arrangements.
2nd. Originating mechanism.
3rd. Conducting and continuing arrangements.

1. *Signals and Alarums.*

These are effected by a number of galvanometer needles, and conducting wires, each of which terminates in a double coil, which acts upon two needles. The form of the coil is that of the figure 8 (only the loops are made rectangular), and in each loop a magnetic needle is suspended. The whole is so arranged that all the needles point north and south. By means of pins, or stops, each needle is prevented from having its signal pole deflected except in one direction. It is then evident that if the electric current be passing in one direction the upper needle only, and, if in the other direction, the lower needle only, will be deflected. This method greatly obviates the objectionable vibration of such needles when suspended in the ordinary way, which vibration is a great impediment to transmitting the signals with sufficient rapidity of succession.

The needles are as follows, being altogether twelve in number:—

4 pairs of letter needles,
1 pair of colour needles,
1 pair of alarum needles.

Letter and Colour Needles.—The deflectable extremity of each letter needle bears three letters, A, B, C, and so on, each differently coloured, say, A red, B black, C white. Which of the three letters is intended for the signal is decided by simultaneously observing the colour needles, one of which has its deflectable extremity red, and the other black. If neither of the colour needles move, the white letter is the intended signal. By this plan the number of needles, and, consequently, of conducting wires, is reduced to the minimum consistent with convenience. One of the colour needles acting alone may, of course, convey some arbitrary meaning, according to the exigencies of the establishment.

Alarum Needles.—Of these only one is essential, so that the other is available for any other purpose required. The alarum needle is shaped so that a suitable piece of card, loaded with fulminating silver, may readily be slipped on to its extremity, which, when the needle turns, is carried round into the heat of a lamp constantly burning beside it. The card is to be renewed as often as it has been exploded, and a number are always at hand for the purpose. This alarum serves to call the attention of the person who is to watch the signals, and the same principle is evidently applicable to other purposes independent of the telegraph.

There are other modes of producing different kinds of alarums, which, by the application of the principle on which the electric currents are continued [*i.e.*, relayed], can be accomplished without difficulty.

II. *Originating Mechanism.*

This consists of—2 galvanic pairs of plates,
2 reversers,
4 pairs of communicating keys,
1 pair of colour keys,
1 pair of alarum keys.

One pair of plates and one reverser belong to the keys of the colour needles exclusively, the other pair of plates and reverser being common to all the other keys. As the action of the two reversers is the same, they may both be included under one description.

The Reverser.—The zinc and copper plates are, each, in communication with a separate cup of mercury, which we may call, severally, the zinc and copper cups. There are two wires, one of which we may call the common communicator and the other the return wire, each terminating in a double, or forked, extremity. To a wooden beam, capable of a certain degree of revolution on its axis, both of these forked pieces are fixed, so that if, in one position, the common communicator is in connection with the zinc cup, and the return wire with the copper cup, a partial revolution of the beam reverses the connections, making the wire from the common communicator now dip into the copper cup, and the return wire into the zinc cup. The reverser is actuated by every alternate communicating key.

The Communicating Keys.—These somewhat resemble the keys of a pianoforte. There is a pair for each wire. Pressure upon the first of each pair causes the point of the line wire connected with it to dip into a cup of mercury continuous with the common communicator, which enables us to establish, or cut off, in the most convenient way, the connection between the galvanic pair at one end, and the signal needles at the other. The second key of each pair, when pressed, turns the reverser before effecting the connection with the line wire, and, consequently, causes a reversed current to flow into the line.

The colour and alarum keys are operated in the same way

III. *Conducting and Continuing Arrangements.*

To command the signals not more than eight conducting wires will be required (probably less). All the letter and the alarum conductors, having, severally, formed their double coils, terminate in a cup of mercury from which a single conducting wire, called the return wire, reaches back to the originating station, where it is in connection with either the copper, or the zinc cup, according as the reverser may be set. The colour needles have a separate return wire*, as well as a separate reverser and pair of plates.

The best mode of laying the conducting wires remains to be determined by experience on a large scale, and the localities through which they may have to be brought. Either they may be somewhat flattened between rollers, and bound together with interposed pieces of cloth, soaked in pitch or rosin, &c., the whole being enveloped with canvas tarred, or impregnated with melted caoutchouc and linseed oil, or the like; or they may be secured in a tube (jointed laterally) of iron or earthenware. In the former case they would admit of *being suspended in the air, from post to post, protected by lightning conductors*, while in the latter they would be laid along, or underground; or they may be separately coiled round with cotton, and bound together, each being of a different colour for guidance in case of repairs.

As it may be more than doubted that an electric current in a circuit of great length, as between London and Dover, or London and Liverpool, would retain sufficient magnetic power to effect the signals after travelling so far, it may be

* Davy's case was backed by the evidence of several confidential friends, as Dr. Grant, Messrs. Thornthwaite and Hebert, and the mechanic who helped to make his instrument. We need not say how the Solicitor-General decided.

† We hope soon to be able to present all these valuable MSS. to the Library of the Society of Telegraph-Engineers and Electricians.

* Davy soon suppressed this, as he found that one return wire would suffice for *all*. He thus reduced the number of line wires to seven viz., four for letters, one for the alarum, one for the colour needles, and one return wire.

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made to renew itself at given intervals, by the following self-acting contrivance:—

The Electrical Renewer.—The principle of this contrivance is that, the total distance being divided in a number of shorter ones, there be a separate galvanic circuit for each, and that, at the termination of each length of wire, its current be made to produce a motion, which establishes a communication between a fresh source of electricity and the wire which extends through the next succeeding distance. For instance, the first portion of wire terminates in a rectangular figure of 8-coil, fixed horizontally, so as to act upon needles, so suspended as to be capable only of vertical motion. Each needle is rendered incapable of motion except in one direction, so that one, or the other, will be deflected according to the direction in which the current is passing. At the end of each needle is fixed a cross piece of copper wire, whose ends are turned downwards. One of these ends is constantly immersed in a cup of mercury, which is connected with one of the plates of a galvanic pair, while the other end dips into a second cup of mercury every time the needle is deflected by a current in the coil. This second cup is the commencement of the next circuit.

To complete the circuit, a corresponding but reverse connection must be made with the return wire, so that while the needle of the signal wire establishes a communication with the zinc, that of the return wire establishes simultaneously a communication with the copper, and *vice versâ*.

By this contrivance it is clear that there can be no physical limit to the distance to which electric currents may be carried; and, therefore, the expense of long distances will cease to be in an increased ratio to that of short ones.

Additional Observations.

(1). The coils herein described may be either simple, or multiplied, as the case may require. It will probably be better that they should be multiplied, than that the needles should be too delicately suspended.

(2). For stopping more effectually the vibration of the needles immediately on their relapse, on the cessation of the current, the following plan is proposed:—A portion of the wire is coiled round a small piece of soft iron, which is rendered magnetic during the passage of the electricity, its polarity varying with the direction of the current. This is so arranged that the end of the needle bears against it, and is held by it, when no current of electricity is passing, or when it is passing in one particular direction, and that, when passing in the other direction, the iron will be so polarized as to repel, instead of attract, the point of the needle.

(3). There is a variety of modes in which different kinds of alarums may be made, when once the principle of the Electrical Renewer is applied, as there is then no limit to the power which may be obtained, and it requires little reflection to suggest a multiplicity of methods of making this power produce sound. A piece of soft iron may be rendered alternately magnetic and non-magnetic, so as to withdraw, when required, the peg of an alarum clock, &c., or a needle may be made to carry round a red hot wire, or match, so as to explode a cannon, &c.

(4)*Portable Telegraphs.*—Such a contrivance might occasionally be useful in warfare. The conductors should then be made in short lengths, each conductor differently coloured for facility of distinction.

(5) *Marine Telegraphs.*—Communications may be effected through, or under, the water by enclosing the conductors in ropes well coated, or soaked, in an insulating and protecting varnish, as melted caoutchouc, &c. The ropes could then be sunk to a certain depth by weights, and supported by small floats, or buoys. In connection with the rope we may have an air-tight and water-tight electrical renewing apparatus [*i.e.*, Relay] at each requisite interval.* On this subject further experiments are necessary.

(6) Land telegraphs may, of course, be made to indicate similar signals and produce similar alarums at numerous places at the same time.

* As in Van Choate's patent No. 156 of January 19, 1865.

(7) Estimated expense of particular lines of communication at £70 per mile, which includes two sets of wires for communicating in each direction.*

From	Miles.	£
London to Dover	71	5,000
„ „ Brighton	51	3,500
„ „ Bristol	119	8,500
„ „ Portsmouth	72	5,000
„ „ Birmingham	109	7,770
„ „ Liverpool	206	14,000
„ „ York	199	14,000
„ „ Newcastle	273	19,000
„ „ Edinburgh	367	26,000
„ „ Glasgow	400	28,000
„ „ Exeter	164	11,500
Liverpool to Manchester	30	2,200
		£144,000

(8) Annual expense of each station, comprising salary of four or five clerks, attendants, rent, and workman to feed the batteries and keep the apparatus in order, £600.

Outlay from London through Birmingham to Liverpool £14,000, or say £20,000, of which the interest at 5 per cent. per annum	£1,000
Expense of three stations, one in each town, at £600 each	1,800
Contingencies	200
	£3,000

which, including Sundays, is about £10 per day; and this, divided by 3, gives £3 6s 8d. as the sum necessary to be received, on an average per day, at each station, in order to pay expenses and return an interest of 5 per cent. for the outlay.

(9) *Capabilities.*—The telegraph constructed on the plan herein described is capable of transmitting about fifty letters in two-and-a-half minutes, but, by an improvement devised subsequently to writing the early part of this description, they may be sent several times as rapidly. In fact, the only limit now appears to be the quickness with which the eye can catch the letter, and the hand note it down.

During the summer and autumn of 1837, Davy effected some important changes in the mode of making the signals. In the plan just described the needles were made to turn horizontally, and the eye was obliged to attend to two movements, at the same time, in order to distinguish by the colour needle, which of the three letters was meant. The oscillation of the needles in settling down to their positions of rest caused a waste of time, and was otherwise a bar to rapid signalling. By the following plan both these disadvantages were obviated without introducing fresh ones:—

The needles were all suspended, somewhat like balance beams, so as to turn vertically, instead of horizontally, and they were made long, so that their ends might describe large arcs, although the movement at the centre might be small. The letter ends were weighted so as, under ordinary circumstances, to dip under cover, but, on the passage of a current, they were raised, so as to bring the letters opposite an illuminated sight groove.

What used to be the colour needles were now provided with small screens, which could be raised, or depressed, in front of the letter needles, so as to conceal, or expose, them at pleasure. Thus, if the letter needle bearing A B C were shown, and neither of the distinguishing needles moved, their screens would lay so as to cover A, and C, B, only being visible. If now one screen, say the top one, were deflected

* It is not that Davy did not know how to make his apparatus reciprocating, so that one set of wires should suffice for to and fro correspondence, but because, as he explains in other places, he thought that when once the telegraph was established there would be more traffic than one set of wires could carry; and he, therefore, recommends here, as elsewhere, the laying down at once of an *up* and *down* set of wires, for exactly the same reasons that we have *up* and *down* lines of railway.

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it would cover B, and expose A, and, similarly, if the other screen were moved it would expose C, and cover B.

In this arrangement the eye had to watch only one signal, and, as all the letters could be arranged more compactly, the field of view was greatly reduced, and the letters could be easily caught and noted down, without the necessity of even turning the eyes.

The next alteration was in the same direction of simplification and perfection of the signalling apparatus, and was a decided improvement even upon the last. It consisted in making the letters immovable, and covering them by three screens in such a way as to be able to expose any desired

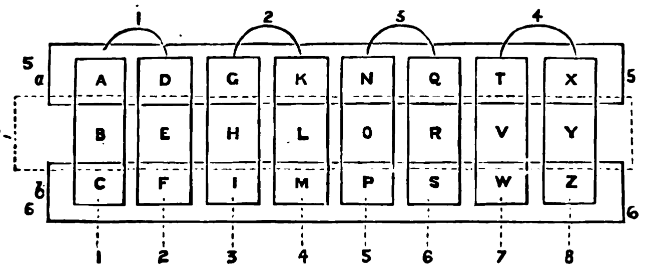

Fig. 3.

letter at will. Fig. 3 shows the arrangement. 1, 2, 3, 4, were pairs of screens, which, when at rest, covered all the letters, ranged in rows of three behind them, and one, or other, of which, in each pair, could be moved aside, according to the direction of the current in the line wire to which it belonged. The screens 5, 5, and 6, 6, answering to the colour needles of the old plan, but now called *triplicators,* were so arranged as, in their normal position, to cover the top and bottom rows of letters, and, on the passage of a current in their coils, to move inward and cover the centre row.

If, now, any one of the letter screens, say that on the extreme left of the figure, were moved aside, only one letter, B, would appear; because A, and all the letters in the top row, would be covered by the triplicator 5, 5, and C, and its fellows in the bottom row, by the triplicator 6, 6; but if one of the triplicators, as 5, 5, had been simultaneously moved, then only the letter A, would appear. Thus, a single movement of a letter screen will expose any letter in the centre row, and a combined movement of a letter screen and a triplicator will exhibit any letter in the top, or bottom, row according to the triplicator employed.

But, as each wire was to be provided with a separate battery, and as the currents could be sent in one direction, or another, in one, or more, wires at the same time, it is clear that one to four letters could be shown at once, *provided* they were all in the same row, and were not covered by the same pairs of screens. Thus, the word B O Y could be signalled at once, by sending, say, a positive current into the first wire (on the left), exposing B, a positive current into the third wire, exposing O, and a negative current into the fourth wire, exposing Y. Again, the word A N T could be shown at once, by sending a current into the triplicator wire, so as to cause the screen 5, 5, to move down, then a positive current sent into the first, third, and fourth letter wires would uncover the letters A, N, T, respectively. In this way, besides being able to show all the letters of the alphabet singly, about 200 different groups of letters could be displayed at one operation, which, by having certain meanings attached to them, would greatly expedite a correspondence.

The needles by which the screens were actuated were, as before, suspended in the manner of ordinary balance beams with horizontal axes; but these axes were now prolonged, and carried tall upright rods, at the free ends of which the screens were fastened. Thus, the slightest movement of the axes produced a considerable deviation of the screens, while their extension permitted of the needles (with, of course, their coils) being placed at sufficient distances apart to prevent their mutual disturbance.

In the working model which Davy had constructed for exhibition all the letter-indicating mechanism was enclosed in a mahogany case, which could serve also as a desk for writing down the signals as they appeared. In the front of the case there was an aperture about sixteen inches long, and three or four inches wide, and this, at ordinary times, was so dark that difference of surfaces of the screens could not be detected, which led to the deception that only one screen was used—a deception which the author purposely planned and encouraged, in order that the *modus operandi* of his instrument might not be divined, which would prevent him taking out a patent for it afterwards, as he contemplated doing.* Behind the screens was a plate of glass, covered with black card-board, out of which spaces, representing the letters of the alphabet, were cut, and behind the glass was a white card-board, on which the light of a lamp was thrown. The result was that, whenever a screen was turned aside, a beautifully white letter appeared to the spectator at the aperture.

A working model, embodying all the author's improvements to date, was shown about November-December, 1837, at the Belgrave Institution, London, and from the great interest which it there excited, Davy resolved upon a more public exhibition; accordingly, he rented a room for one year in Exeter Hall, and there installed his telegraph from December 29, 1837, to November 10, 1838.†

A writer in the *Mechanics' Magazine*, for February 17, 1838, thus describes the exhibit. It will be observed that, for the reason which we have given above, his language in places lacks clearness, but this is of little consequence, for we, who are now in the secret, can easily follow him:—

DAVY'S ELECTRICAL TELEGRAPH.

Sir: The favourable notice of your correspondent, "Moderator,"‡ on the subject of Mr. Davy's electrical telegraph, induced me to visit Exeter Hall, for the purpose of carefully inspecting the invention; and I am enabled to bear testimony to the general accuracy of your correspondent's remarks, and also of the great pleasure I experienced in the investigation of the apparatus. Under these circumstances I beg to offer a few additional remarks, in some measure corrective of those made by "Moderator."

As a preliminary observation, I would suggest to the inventor the necessity of removing to some other part of the building, or, if that cannot be accomplished, of quitting the place altogether, and locating himself in some situation where his light may not, literally, be "hid under a bushel." He appears to be surrounded by rooms under repair or alteration, and his delicate apparatus is, consequently, smothered with dust; the room is also small, dark, and altogether of most unpromising appearance.

In front of the oblong trough, or box, a lamp, described by your correspondent, is placed, and that side of the box next the lamp is of ground glass, through which the light is transmitted for the purpose of illuminating the letters. The oblong box is open at the top, but a plate of glass is interposed between the letters and the spectator, through which the latter reads off the letters as they are successively exposed to his view. At the opposite side of the room a small key board is placed (similar to that of a pianoforte, but smaller) furnished with twelve keys; eight of these have, each, three letters of the alphabet on their upper surfaces, marked thus, A. D., and so on. By depressing these
B. E.
C. F.
keys in various ways the signals, or letters, are produced at the opposite desk as previously described. How this is effected is not described by the inventor, as he intimated that the construction of certain parts of the apparatus must remain *secret*. By the side of the key board there is placed a small galvanic battery from which proceeds the wire, twenty-five yards in length, passing round the walls of the room. Along this wire the shock is passed, and operates upon that part of the apparatus which discloses the letters, or signals.

The shock is distributed as follows:—The under side of

* This little *ruse* explains the fogginess of all accounts of Davy's telegraph hitherto published. See foot-note on page 181.

† Davy's MSS. See also *Mechanics' Magazine*, for January 20, 1838, and "The Electric Telegraph Company *versus* Nott and others," Nott's and Grano's affidavits. The room occupied by Davy was that known as No. 5, for which he paid rent at the rate of £35 per annum.

‡ Correctly, "Moderatus," in *Mechanics' Magazine*, for February 3, 1838.

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each signal key is furnished with a small projecting piece of wire, which, on depressing the key, is made to enter a small vessel filled with mercury, placed under the outer end of the row of keys. A shock is instantly communicated along the wire, and a letter, or signal, is as instantly disclosed in the oblong box. By attentively looking at the effect produced, it appeared as if a dark slide were withdrawn, thereby disclosing the illuminated letter. A slight vibration of the (apparent) slide occasionally obscuring the letter indicated a great delicacy of action in this part of the contrivance, and, although not distinctly pointed out by the inventor, is to be accounted for in the following manner:—When the two ends of the wire of the galvanic apparatus are brought together over a compass needle the position of the needle is immediately turned at right angles to its former one; and again, if the needle is placed with the north point southward, and the ends of the wire are again brought over it, the needle is again forced round to a position at right angles to its original one *(sic)*. Thus it would appear that the slide, or cover, over the letters is poised similarly to the common needle, and that, by the depression of the key, a shock is given in such a way as to cause a motion from right to left, and *vice versâ*, disclosing those letters immediately under the needle so operated upon.

A gentleman present hazarded a doubt as to the shock being energetic enough for a considerable distance. The inventor replied that he was in possession of means that would enable him to convey intelligence to any distance that may be required. Whether this was to be effected by *coils* of wire at intervals was not stated; such, however, appears to me a reasonable supposition. The difficulty of *tubing* for the protection of the wire was discussed. I took the liberty of suggesting the employment of a proper-sized *tobacco pipe tubing*, which was received with satisfaction. It was also stated by a gentleman present that he was in possession of a smaller battery than that at Exeter Hall, and had obtained from it a power equal to *forging* iron plate; it will, he said, be shortly produced.—Yours respectively [*sic.*],

CHRIS. DAVY.

3, Furnival's-inn, Feb. 5, 1838.

(TO BE CONTINUED.)

BOYS' ENGINE POWER METER.

We have often pointed out that an electrical engineer should have the education and experience of a mechanical engineer, as well as the special knowledge of electrical subjects. He must not only know such methods of measurement as enable him to deal with E.M.F., current, resistance, &c., but must be quite as familiar with dynamometers, indicator diagrams, and so on. Any instrument, then, that is designed to simplify these measurements is of interest to electrical engineers. Mr. Boys claims to have designed a simple apparatus that will do all and more than the ordinary indicator, with an expenditure of less labour to the user. The instrument is manufactured by the Electrical Trading Company, who have issued a descriptive pamphlet as to the theory, construction, and practical applications of the meter. We understand that the instrument is used with very satisfactory results by Messrs. Nettlefolds, the India Rubber, &c., Works, and others.

This meter is designed for the purpose of directly measuring and recording the work done by steam, gas, water, and hot-air engines. The instrument, instead of merely indicating by a diagram the variation of effective pressure during only a single stroke of the piston, and leaving the result to be subsequently interpreted, shows clearly at a glance, the actual working efficiency of an engine during any particular stroke it may be desired to observe. It does more than this, it automatically and continuously registers the total work done from the moment the engine is started till it is stopped.

With the exception of the power meter the machines at present in use for measuring the work done by an engine are all modifications of the well-known indicator invented by Watt and improved by Richards. A diagram must be taken, and the area of the diagram has to be computed.

In the meter of Mr. Boys this computation is effected continuously by ingenious but simple integrating mechanism, and recorded with precision upon a dial, from which the result may be read off at any moment. Although Mr. Boys' meter differs very widely in its general principles from any existing indicator, it resembles, in several fundamental points of its construction, the ordinary Richards machine. Indeed, a very fair notion of its leading features may be obtained by imagining that the pencil and supplementary link-work of the indicator is replaced by a single arm carrying a small wheel which presses upon a cylinder so arranged as to slide longitudinally upon its axis and yet rotate therewith. The remarkable effect of the ingenious contrivance by which this idea is carried out is, that instead of merely tracing a diagraphic figure with a pencil—and for only one stroke of the engine—the machine, in accordance with certain mathematical principles, becomes at once a meter, which, without really drawing the figure, actually measures its area from instant to instant, adds up the results continuously—presenting the total upon a dial after the manner of a gas meter.

Fig. 1 shows instrument open, with diagram attachment.

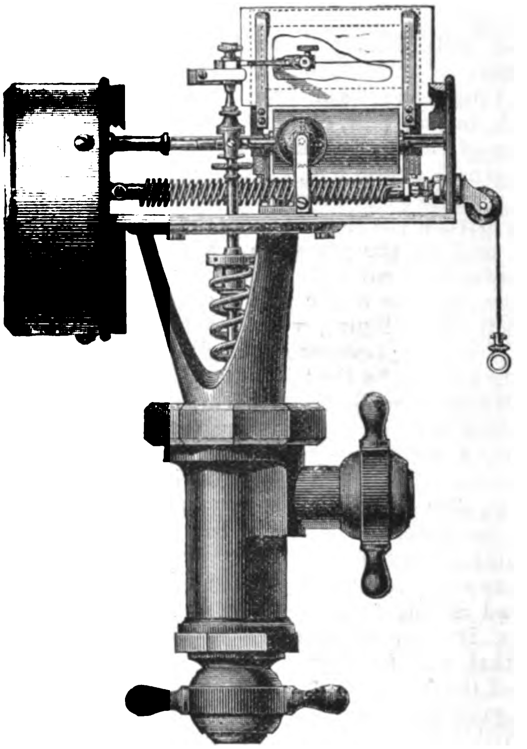

FIG. 1.

A spiral spring around a piston rod attached to the piston within the cylinder are the parts somewhat similar to the indicator. A horizontal cylinder slides longitudinally upon an axial rod, but keyed thereto, so that axle and cylinder must revolve together. A tangent wheel, turning upon the pivots of a crutch that moves upon a horizontal axis, is kept pressed upon the cylinder by a spring, so as to be always in rolling contact with the surface of the cylinder. An arm in the plane of the tangent wheel, and perpendicular to its axis, passes through a pivot attached to the end of the piston rod. The displacement of the meter piston (= the effective pressure on the engine piston) is measured by the tangent of the angle through which the plane of the wheel is rotated; for which reason this wheel has been appropriately called the "tangent wheel." The integrating cylinder is carried in a frame which moves to and fro with the piston of the engine, being pulled the one way by a wire, and the other by a spring. By this arrangement the continued reciprocation of the integrating cylinder with that of the engine piston is ensured, and the velocity of the one kept at every instant proportional to that of the other. So long as

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the tangent wheel is horizontal, and therefore in the same plane as the axis of the integrating cylinder—that is, so long as the tangent wheel occupies its normal position—the reciprocation of the integrating cylinder will be unaccompanied by any rotation about its axis; but should the meter piston be displaced by ever so small an amount, the plane of the tangent wheel will be at once inclined to its normal position, and therefore to a straight line on the surface of the cylinder and parallel to the axis that passes through the point of contact of the tangent wheel. The immediate result of this will be to cause the integrating cylinder, as it reciprocates in contact with the inclined tangent wheel, to turn upon its axis—the surface of the cylinder passing under the tangent wheel in a screw line. Clearly enough, the greater the inclination of the tangent wheel the greater will be the rotation of the cylinder; but, in the absence of a clear knowledge of the mathematical relation between the amount of the rotation of the integrating cylinder and the two other factors of the problem furnished (1) by the inclination of the tangent wheel, and (2) the rectilineal displacement of the integrating cylinder, no valuable practical application of the idea could possibly be made. What, then, is the law of this relation? It is remarkably simple, and may be stated briefly thus:—The amount by which the integrating cylinder rotates is directly proportional to the product of its rectilineal displacement into the tangent of the angle of inclination of the tangent wheel—which angle is, of course, the complement of the angle of the screw line forming the path of the tangent wheel on the surface of the integrating cylinder. But, inasmuch as the rectilineal displacement of the integrating cylinder is, by the nature of its connection with the engine piston, proportional to the motion of the latter, and the tangent of the angle of rotation of the tangent wheel proportional to the displacement of the meter piston, which displacement, being opposed by the resistance of a spiral spring, measures the effective pressure of the engine piston, it follows that the amount by which the cylinder rotates is rigidly proportional to the product of the pressure in the engine piston into the distance through which it is moved. This, however, measures the work done by the engine, and therefore the amount of rotation of the integrating cylinder is an accurate measure of the available engine power.

The following is the practical mode of using the instrument, as described in the pamphlet referred to:—

The meter is connected with the engine somewhat similarly to a Richards indicator by pipes and taps of large bore. The lower end of the meter cylinder should be placed in communication with the end of the engine cylinder opposite the piston rod, and the upper end connected with the corresponding end of the engine cylinder by means of union joints. The steam being turned off by means of the cocks, a suitable spring must be screwed into its place in the meter, and the union joint at the neck loosened so that the top may be turned easily into a convenient position. Remove the cap of the meter and attach a piece of fine piano wire, by means of a loop, to the terminal hook of the spring band, which will be found fastened to the integrating cylinder. The other end of the piano wire must be properly attached to some moving part of the engine, so that as the piston rod reciprocates the integrating cylinder may be caused to move to and fro with it through the space of about $1\frac{1}{2}$ inch. Turn the back of the upper part of the meter towards that portion of the engine to which the wire is attached, so as to let the pull come straight on the band, and lengthen or shorten the piano wire, so that the saddle of the integrating cylinder is not bumped against the bearings of the shaft which carries it. The instruments allow of nearly two inches play, so there ought to be an easy $\frac{1}{4}$ inch on each side. Next let the engine draw the integrating cylinder to and fro several times, so as to push the sliding collars to their extreme position, and then measure accurately the distance between them and determine n. Assume, for example, that $n = 1{\cdot}41$ inch, and that M, or the engine stroke, $= 20$ inches. Then $\frac{M}{n} = \frac{20}{1{\cdot}41}$. Taking $D = 15$ inches, and $s = 150$, and inserting these values into the formula that presents the value of a complete revolution of the meter cylinder, we get

$$\frac{M}{n} \times \frac{\pi a l s D^2}{12 d^2} = \frac{20}{1{\cdot}41} \times \frac{3{\cdot}1416 \times 1 \times 1 \times 150 \times (15)^2}{12 \times (1)^2} = \text{foot}$$

pounds of work for one revolution of the meter cylinder or x units as shown on the dial. Now, x, π, a, l, and d are fixed when the instrument is made, and may, therefore, be replaced by a constant, c. Thus the actual working formula is simplified at once, and becomes $\frac{M}{n} \times D^2 s C$. Every meter has the value of C accurately computed and confirmed by a practical test, and then marked in the lid of the box for reference. s, the value of the spring, is carefully tested in each case, and stamped upon it before being sent out. All, therefore, that remains to be done by the person who first sets the instrument to work is to find the values of M, n, and D, as stated above. These are M, the stroke of the engine in inches, D its diameter, also in inches, and n the longitudinal motion of the

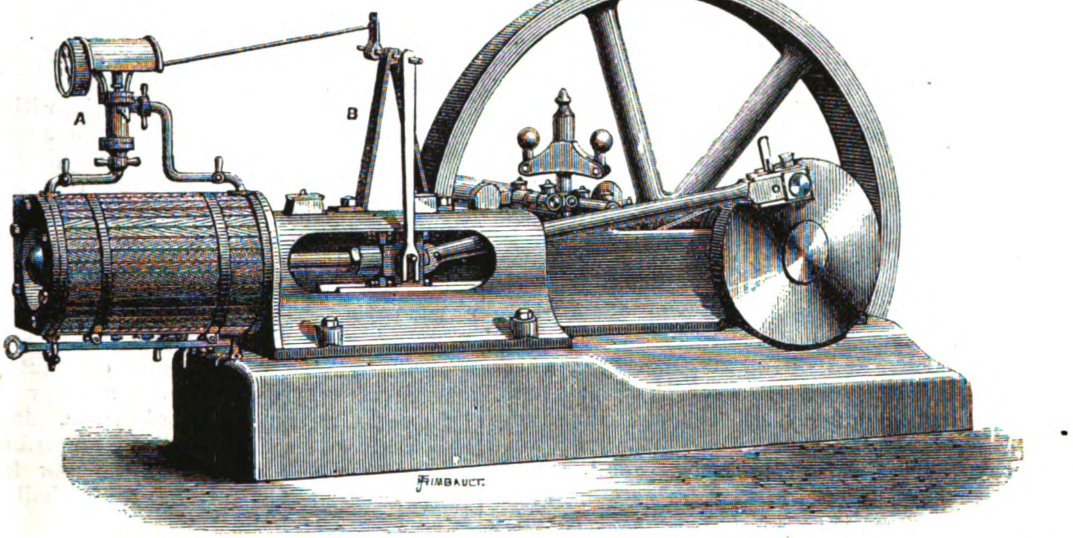

FIG. 2.—Showing Boys' meter (A) fitted to a horizontal engine, in a position similar to that of an ordinary diagram indicator. The supports and arms (B) connecting the meter with the piston rod of the engine are exactly the same as those used with the ordinary indicator in general use.

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integrating cylinder. The formula $\frac{M}{n} \times D^2 s C$ will then give without further trouble the value in foot-pounds of the meter unit for the particular engine to which it is applied.

Once obtained, this number is absolutely fixed, and if it is desired to know how many foot-pounds of work have been done during, say, the day's run of the engine, we have merely to determine the recorded units, as in a gas meter, and multiply the number by this constant. For the average horse-power of the day the number of foot-pounds must, of course, be divided by 33,000, and by the time in minutes, or the number of units run in a minute multiplied by the value of the meter unit, and the product divided by 33,000 will give the true horse-power. The result would not, of course, in this case, be such a fair sample of the engine's work as that deduced from a day's or week's run—but it would be infinitely better than the horse-power deduced by an ordinary indicator for a single stroke.

The following easy rules are all that are necessary to observe in the practical use of the meter:—

1. To determine the number of foot-pounds of work done in any given time:—Note the number of units shown on the dial at the commencement and end of the period, subtract the one from the other, and so find the units run during the time. This number, multiplied by the meter unit, gives the foot-pounds of work done by the engine during the interval.

2. To determine the horse-power of the engine at any particular time:—Note the units run in a minute, or the average per minute during a number of minutes, and multiply by the foot-pound value of the meter unit. The product divided by 33,000 will be the horse-power.

Every engine has its own constants easily determined as above; but, if desired, the meter will be specially constructed at a small extra cost for giving foot-pounds direct, or so that the units read off in a minute give horse-power; but this is not recommended, as for this purpose it would be necessary to send the constants of the engine with the order, and no real advantage secured.

The care of the instrument requires that all the working parts should be slightly oiled occasionally, except the surface of the integrating cylinder and of the tangent wheel, which should be kept as clean as possible. The gilt spring should be sometimes examined, wiped dry, and cleaned with an oily patch.

When at work the instrument presents several notable points of interest. For example, when "cushioning" exists the index goes back a little at each stroke, showing negative work. Also, if the steam is suddenly turned off, so that the engine continues in motion only from the inertia of its moving parts, the negative work done is recorded on the dial by a backward motion of the index. The instrument, in fact, is perfectly accurate, showing only the real effective work of the engine, and not imaginary estimates of its possible power.

ON THE PENTANE STANDARD, AND ON A NEW FORM OF PHOTOMETER.*

BY A. G. VERNON HARCOURT, M.A., F.R.S.

It is no longer necessary, in addressing an audience familiar with photometry, to preface the account of a proposed standard of light with a statement of the defects of the existing standard. That sperm candles of six to the pound, burning 120 grains (more or less) per hour, may give from 1-15th to 1-18th of the light given by five cubic feet of common gas supplied hourly to a London argand, the standard changing while the quality of the gas supposed to be tested by it remains unchanged, was proved long ago. The strength of a chain is the strength of its weakest link; and there is something ludicrous in the pains we bestow upon all the details of photometry, providing for a most exact comparison between our carefully-manufactured gas and a standard which goes up and down as we look at it. We English are apt to be credited with skill and care in matters of technical science; and probably no industry better deserves this credit from our neighbours than the manufacture and supply of coal gas. It happens, consequently, that letters are received from time to time by the metropolitan gas referees, from some colonial or foreign authority, asking for information as to our method of estimating the illuminating power of coal gas, which they are sure will be of great value for their guidance. They are not pleasant letters to answer. One has to choose between communicating the details of the apparatus and the elaborate precautions we prescribe (smiling the while at the little good it will do them); or, on the other hand, avowing that our careful and costly system of photometry is valueless because we use a fluctuating standard.

Two remarks as to the causes of the variation of candles may here find a place—one relating to the wicks, the other to the place in which they are burnt. Many of us can remember back to the days of snuffers, and the dimness which came on as the candle-wicks grew longer, and the sudden brightness which came from the application of the snuffers. The chief cause of the unequal light given by one standard candle and another lies in the greater or less perfection of the self-snuffing which the curvature of the wick produces. For the same consumption of sperm, the light given by two candles will be widely different of which one has a wick bending over through a right angle within ¼in. of the cup, and keeping the cup full of melted sperm, while the other has a thick loosely-plaited wick standing up about ½in. within the flame. The second cause of variation is the greater or less movement of air in the room or other enclosure within which the candle burns. Some trials on this point have recently been made at the Cheltenham Gas Works, with the result that the same candles tested alternately in a small room with no more space than the photometer requires and in each of two good-sized rooms with ordinary ventilation, burnt in the latter case about 120 grains per hour, and less than 110 grains in the former case. The light of the candles was not measured; it varies in such cases with the consumption, but in a much greater degree.

In 1877 I brought before the Chemical and Physical Sections of the British Association a method of producing a standard flame from a gas of constant composition and a burner of very simple construction which gave the same light as the average standard candle. It is to a proposal for substituting this standard flame for ordinary sperm candles in photometry, and also to the new form of photometer which stands at the entrance to the hall, that your attention is now invited.

An account of the pentane standard is given in the paper to which reference has been made, and a further account in a letter to the Board of Trade, printed two years later, as well as in the subsequent report of the committee on photometric standards. But as the standard has not been brought under the notice of the Gas Institute, and is not widely known, it may be well to describe the manner in which it is produced and may be reproduced anywhere and at any future time, at least until the petroleum wells have run dry.

The liquid used for the preparation of the standard gas is the most volatile portion of American petroleum, obtained by first purifying the "gasoline" of the air gas companies by agitation with oil of vitriol and with solution of caustic soda, and by then rectifying the product by repeated distillation till the whole passes over at a temperature of 120deg. Fahr. The liquid thus obtained consists of nearly pure pentane—a hydrocarbon bearing the same relation to amyl alcohol, or fousel oil, which marsh gas bears to ordinary alcohol, and having the formula $C_5 H_{12}$. It vaporises more quickly than ether, and has the indispensable property which ether has not of being insoluble in water. Its purity can readily be tested by weighing a measured quantity. Calling water 1,000, the specific gravity of pentane at 60deg. is between 628 and 631. Its vapour is 2½ times as heavy as air. A convenient quantity of the standard air gas to make at one time is 4 cubic feet. This is made by drawing into a small gasholder 3 cubic feet of air, and then discharging into it a pipette holding 9 cubic inches of pentane. In a few hours the gas is made; and since the rate of burning is half a cubic foot per hour, and a testing does not occupy more than five

* A paper read before the Gas Institute.

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minutes, the gas thus made will serve for nearly 100 testings. The volume of vapour which adds itself to the 3 cubic feet of air as the pentane vaporises amounts to 1·05 cubic foot, and if the experimental gasholder gives the means of reading the volume of its contents, the reading of the increase in volume serves to show whether the gas has been rightly made. An account of experiments upon the effect of small variations in the quality of the pentane and in the proportion of air is to be found in the papers to which reference has been made, showing that with moderate care no appreciable variations in the standard flame are likely to arise from these causes.

From the gasholder the standard air-gas passes through a small meter and governor to the burner, which consists of a brass tube 4in. in length and 1in. in diameter, plugged with a disc $\frac{1}{2}$in. in thickness, through the middle of which is drilled a $\frac{1}{4}$in. hole. Gas issuing under a pressure which no gauge would show is apt to burn unsteadily, and to protect the flame with a chimney would, to a small extent, affect the light, partly by interception, but chiefly because imperfection in the glass, otherwise imperceptible, may cause a slight convergence or divergence of the rays. But it is found that a flame almost as steady as that of a candle is obtained by making the flat top of the burner four times as wide as the orifice, and by placing a chimney round the burner to guide the air currents which rise from the heated sides of the burner and form an invisible chimney.

The air-gas must be turned up or down till the flame touches, without passing, a fine wire stretched $2\frac{1}{4}$in. above it. If the height of the flame be carefully adjusted, small variations in the quality of the gas, and consequently in the rate at which it burns, may be made without affecting appreciably the amount of light sent forth by the flame; and even large variations, made purposely, have been found to produce a relatively small effect. But the rate of burning will generally be found to lie between 0·48 and 0·52 cubic foot per hour.

By many trials and a gradual adjustment of the quality of the air-gas and the height of the flame, the standard has been made to correspond to the average of a number of sperm candles. How far the attempt to produce a constant standard of light representing the ideal sperm candle has been successful it is not for the writer to say; but he may be allowed to quote the verdict of the committee on photometric standards:—

"*Sec.* 4.—Compared with the sperm candle, Mr. Harcourt's air-gas flame is exact and trustworthy as a standard of light. We have had before us Mr. Harcourt's letter of April 8, 1879, addressed to the Board of Trade; and his statements, both with regard to the untrustworthiness of the sperm candle, to which we have already referred, and to the advantages of the air-gas flame as a standard of light, are entirely borne out by our investigations. The flame is not subject to the chief sources of variation which affect the amount of light emitted by a sperm candle, and those variations to which it is subject are under the control of the operator. . . . The extreme difference obtained by two observers in 19 determinations, by Mr. Harcourt's method, of the illuminating power of a specially-stored coal gas was 0·3 candle, or 1·8 per cent.

"*Sec.* 5.—The further question of the relation of Mr. Harcourt's air-gas flame to the variable candle standard having been referred to us for determination of the Board of Trade, we have made the comparison by determining the average illuminating power of a specially-stored sample of coal gas alternately by means of the standard candles (as at present supplied to the official testing places) and by the air-gas flame. The average illuminating power of the coal gas, according to the sperm candles, was 15·99 candles for the fortnight the experiments lasted. According to the air-gas flame the average illuminating power of the coal gas during the same period was 16·02 candles. Thus we found the average value of the sperm candle to be practically identical with the light given by the air-gas flame."

The committee proceed to recommend that for the determination of the illuminating power of coal gas the use of the sperm candle should be discontinued, and that for the future the air-gas flame should be employed instead, as a means of affording with constancy the light of one average sperm candle.

But the recommendation of a committee is without effect, unless either the old standard is abolished and a new standard substituted by Act of Parliament, or those who carry on unofficial testings for their own information are persuaded that the plan recommended is worth a trial. The Board of Trade have been prevented by the block in the House of Commons, which has suspended many more important measures, from bringing under the notice of Parliament the question of a change in the standard of light. Until a change has been sanctioned, candles must be used in all official testings made under the Gas Works Clauses Act. But, in the meantime, the adoption at gas works of a mode of testing which would give at any time the true value of the gas, would both supply useful information as to the effect of any change in the coal or the mode of working, from day to day, and from year to year, and would also furnish evidence whenever an unfavourable return by the official tester was due to some eccentricity in the candles used. Mr. Hawksley says that, since more gas than formerly is extracted from a ton of Newcastle coal, the illuminating power of the gas must be less, no matter what the number of candles to which it is found equal; and, in the absence of any trustworthy standard by which the gas of the present day can be compared with the gas of ten or twenty years ago, it must be admitted that the evidence of photometry is worth very little in the matter.

(TO BE CONTINUED.)

PRACTICAL TELEPHONY.

(CONTINUED FROM PAGE 166.)

TWO OR MORE BELLS ON ONE CIRCUIT.—Where it is necessary to have two or more bells on one circuit, it is a very great advantage to be able so to arrange them that the ringing

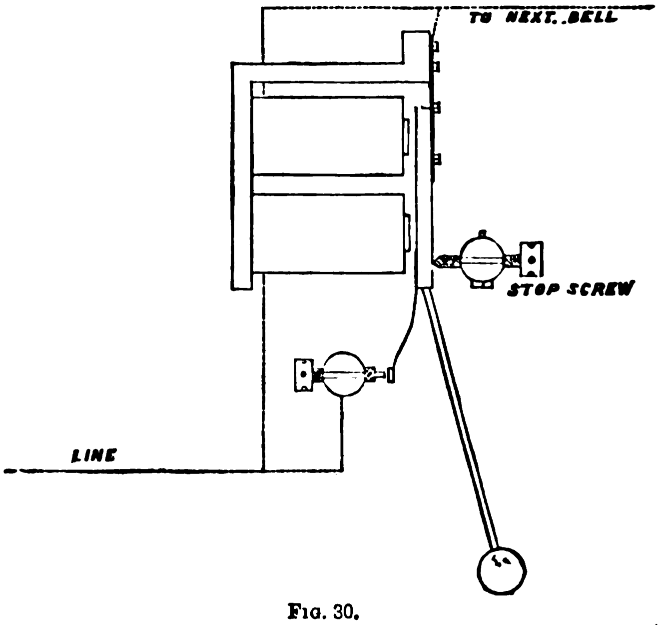

FIG. 30.

of one will not interfere with the ringing of the other. This is usually attained by employing one vibrating and the remainder single-stroke bells, the whole being in series. A much better plan is to place the bells (all vibrating) in series, and each bell should govern its own vibrations, not by breaking the circuit, which would interfere with all the other bells, but by shunting its own coils. This leaves the circuit closed for the other bells. Directly the armature falls back the coils are put again in circuit, and the armature attached. This method is shown by Fig. 30. The remarks for adjusting bells apply in exactly the same manner to extra bells, which are merely ordinary electric bells. For telephonic work the bell coils should have a resistance of about 30 ohms; when in good order and properly adjusted the bell should ring well through a resistance of 70 ohms, using four batteries of four cells.

SWITCHES AND THEIR APPLICATIONS.—Switches must be

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placed amongst the most important of the appliances used in telephony. Not a single station can be fitted up without a switch in some form, either automatic or worked by hand as required, whilst an exchange or switch room, as its name implies, may contain as many as a thousand, or even more. It will be sufficient for our purpose to group switches into two classes, viz.,

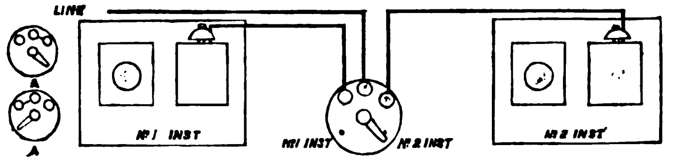

Fig 31.

those used by subscribers and those used in the switch room by the operators.

Switches used by Subscribers.—The purposes to which switches are applied in this case are connecting two or more

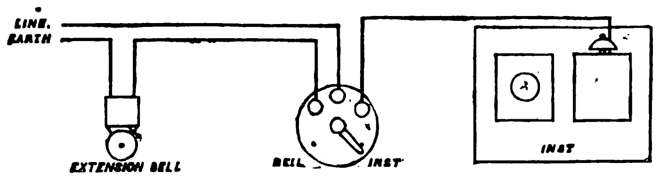

Fig. 32.

lines to one instrument, two or more instruments to one line, or connecting an extra or extension bell, as it is called, to ring at some distance from the instrument, as the various requirements of the subscribers demand. They are also used to prevent subscribers making an illicit use of lines or apparatus.

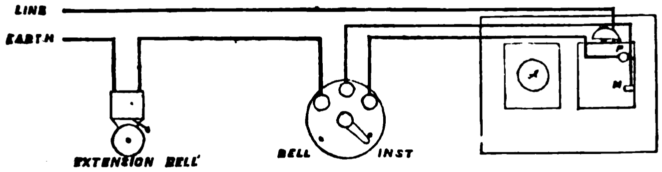

Fig. 33.

Three Point.—The simplest form is that known as the Three Point, Fig. 31. When connected, as shown in this figure, one line can be connected to either of two stations, one situated near the switch, the other at any required distance; for instance,

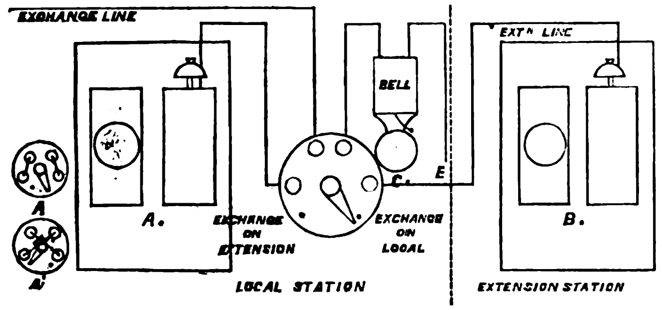

Fig. 34

another office or a medical man's bed room. Fig. 32 shows connections for a single line and instrument, the switch being near the instrument and an extension bell, which may be placed where it can be better heard, for night use,

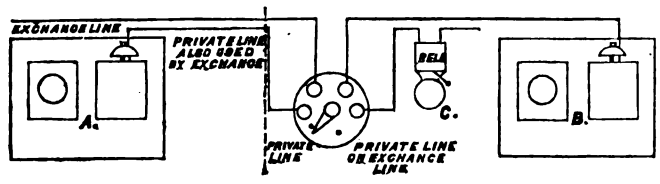

Fig. 35.

&c. When thus arranged the switch must be turned to instrument side before the call signal can be answered. When done the handle must be again turned to bell side. Fig. 33 has been successfully adopted by the writer to obviate the necessity of moving the switch. When turned to bell side, the line goes direct to line terminal as usual, the centre or handle terminal on switch is connected to bracket M or its equivalent, the right hand terminal on switch to bell post P, the wire ordinarily connecting M and P must be removed (see also Fig. 25, p. 136). The switch then acts only on the bell, and speaking can be carried on without moving the switch. A A′ shows the passage of current through switch according to direction of handle.

Four-point (commutator) Switch.—This switch, Fig. 34, is used, connected as shown, in the case where an exchange line extension is used, and where it is required to prevent the exten-

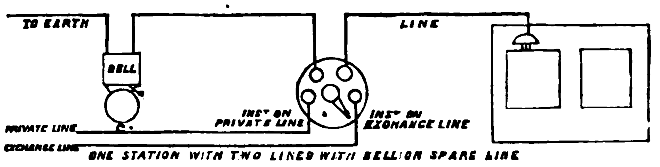

Fig. 36.

sion being used as a private line between the two instruments A and B; at the same time it allows the bell C to be rung, to indicate that the extension station desires to communicate with the exchange. The handle should be kept to the right. Fig. 35, the switch, connected as here shown, enables a private line to be used as part of an exchange line, but prevents the instrument nearest the exchange being used for speaking to the exchange. Instrument A is at the distant end of the private line. B the instrument switch and bell at the end of private line nearest exchange. When the handle is to the right, A is in direct communication over the private

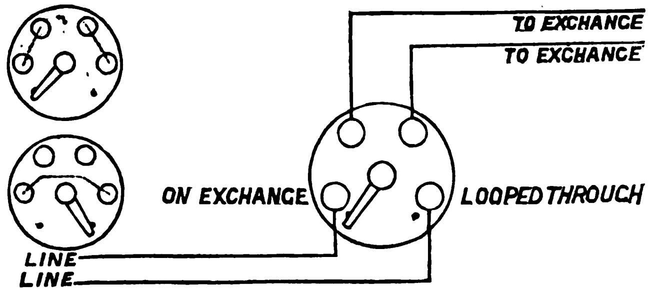

Fig. 37.

line to the exchange, when to the left its normal position A and B can then communicate over their private line, and should the exchange call the extra bell *c* rings. B must then move the switch to the right. A can then answer the exchange. Fig. 36 switch connected as here shown, enables one instrument to be used for both exchange and private lines. When the private line is to instrument, the bell C is on exchange line, and *vice versâ*. At the same time, the two lines cannot be put through. Fig. 37 switch connected for a battery commutator.

Six Point.—Fig. 38 shows the connections for the original

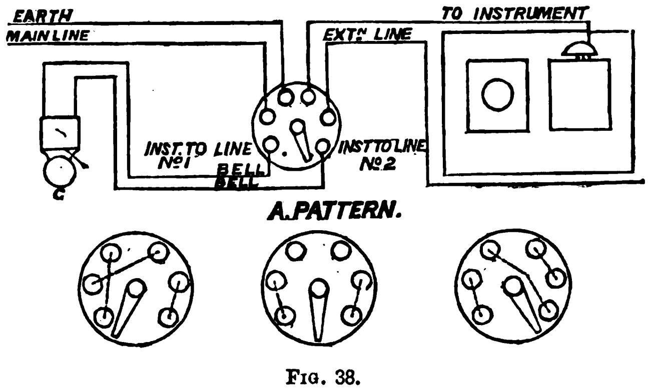

Fig. 38.

pattern six point. It is used on an extension of either a private or exchange line. When the handle is to the right the intermediate and extension instruments are connected, and calls from main line, are received on the extra bell *c*; when to the left the intermediate is connected to main line, and the extra bell *c* to extension line; and, lastly, when the handle is in the central position, the main and extension lines are connected, the intermediate instrument is cut out, but the bell *c* is inserted in the circuit so that the intermediate station can be signalled to disconnect. To illustrate the use of this the intermediate station

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can be in the clerk's office. They then answer the calls: if important, they can ask the principal if he will speak to the person calling. If he wishes to do so, the switch is placed in the central position, and the clerk's office cut out. When the communication is finished, the clerk's office is signalled to replace the switch into its normal position. Fig. 39 is merely the latest

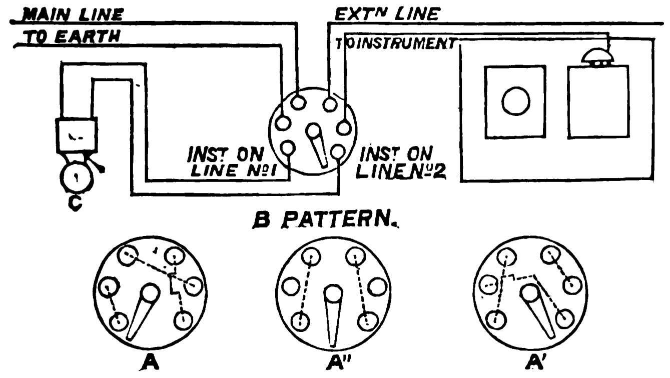

Fig. 39.

pattern switch connected up to correspond with the change of internal connections. Its action is precisely the same.

A A' A'' shows the passage of the current through the switch; the handle has three positions, left, right, and central.

(TO BE CONTINUED.)

LONDON AND GLOBE TELEPHONE AND MAINTENANCE COMPANY (LIMITED).

The second ordinary general meeting was held at St. Michael's Hall, George-yard, Lombard-street, on the 4th inst., under the presidency of Mr. Stewart Pixley.

The Secretary (Mr. J. Ford) having read the notice convening the meeting,

The Chairman said: Gentlemen, although the present meeting is in fact the second ordinary general meeting of the Company, it is, as regards the present shareholders, their first meeting. The Company was registered in January, 1882, and the first or statutory general meeting was held in due course. Thus this meeting becomes a second ordinary meeting. The capital of the Company was not subscribed until the end of August, 1882, and the shareholders will doubtless remember the strenuous efforts made by the United Company by advertisements to discourage intending subscribers. These were not successful, as you know, and an allotment was made towards the end of August last. This period being in the height of the holiday season was not favourable to immediate action. Moreover, the Postmaster-General's license had not been obtained, because it was known that he would only grant his license to a responsible corporation with a sufficient capital. Mr. Eldred's experience as a telephone constructor for carrying on the operations of the Company in regard to establishing exchanges in the metropolis and developing the business generally was very valuable. In this connection it may be mentioned that Mr. Eldred has had a vast experience in America in telephone business, most of the early telephone exchanges in different parts of the United States having been planned and carried out by him. I visited America in the autumn of last year, and whilst there took considerable pains to inquire into the nature and character of telephone business as carried on in the United States, and it will be sufficient for this purpose to say that the result of my inquiries convinced me that telephone business in this country is still in its infancy. Mr. Eldred wanted to go away for a short time to the United States, but as soon as he returned active operations were commenced, with a view to establishing the Company's telephone business, although at that time the Postmaster-General's license had not actually been granted, but it was understood the Company would secure it. The license was not, in fact, signed until the 31st of January last, but between the date of Mr. Eldred's return and the date of the license satisfactory progress had been made in arranging routes and obtaining way leaves for the metropolitan exchanges of the Company. The shareholders probably have but little conception of the difficulty encountered in running overhead wires in a large city like London. Telegraph wires of different descriptions have been run from time to time either by public companies or private individuals, so that it requires the greatest skill and management to secure routes for new wires. The public, too, have been uneasy with regard to these wires, and as it is, of course, necessary to erect fixtures on houses to carry the wires, this uneasiness has made the task of obtaining way leaves and the right to fix poles one of additional difficulty. These difficulties have, it is believed, been in great part overcome, but not without very considerable delay and a not inconsiderable expense, a large staff having to be organised and employed to secure to the Company the rights and privileges they required. The result is that at the present moment the Company are the owners of rights or way leaves numbering considerably over 1,000, they have erected over 400 poles, and run several hundred miles of wires. Offices have also been secured for the exchanges, and the connecting up of subscribers with such exchanges has already commenced, and the directors believe that in a very few weeks they will be able to show a subscription list which will not do discredit to the exertions which have been made. Whilst on the subject of wires and way leaves, it is proper to refer to the difficulties which have been met with in this respect at the hands of the United Telephone Company. It is with considerable reluctance that the directors have referred in their report to the opposition this Company has met with from the United Company. There is ample room in this great metropolis, much more in the United Kingdom, for half a dozen telephone companies to carry on a lucrative business; but the United Company, for reasons best known to themselves, have from the very outset not only put every difficulty in the way of the promoters of this Company, but of the Company itself, after its capital was subscribed, in doing business. The object of this opposition is now plain. The United Company have determined, if possible, and at any expense, to strive for a monpoly of the telephone business in the metropolis. As soon as the United Company found this Company establishing its routes and lines for exchanges, it did all in its power to oppose and obstruct the Company in its operations. With regard to way leaves it may be summed up in a few words, that in every possible instance the United Company have tried to block out this Company's lines, and prevent available routes from being secured. This opposition, carried as far as the criminal prosecution of this Company's assistant general manager and some of its servants, has not succeeded, and the directors have good reason to be satisfied with what has been done by their construction manager in these respects, and to regret only that opposition which has been met with has been productive of more delay than was anticipated. More recently the United Company have made attempts to prevent this Company from using any telephone instruments whatever. These attempts have failed, because the directors believe they have sufficient instruments to answer all purposes for some considerable period, and the directors trust the shareholders will now day by day hear of increased activity with regard to the Company's business and daily increase in the number of subscribers to the Company's exchanges. That the Company have yet difficulties to contend with the directors do not desire to conceal. The recent litigation commenced by the United Company against this Company—three Chancery actions having lately been launched by the United Company—must be contested, and the rival company will doubtless, if they carry out their opposition in the spirit in which it has hitherto been conducted, use every opportunity of harassing this Company, by litigation or otherwise, regardless of consequences, and in the hope that the proceedings will embarrass the action of this Company and thereby secure the monopoly which the United Company are endeavouring to obtain. The directors would remind the shareholders that telephone business is of a somewhat novel and very peculiar character. It takes time to develop, but with patience and means at command the directors believe that success must eventually attend the efforts of this Company, and having regard to the small amount of capital upon which this Company has to pay a dividend, compared with the enormous capital of rival companies, success in this case, in the view of the directors, means a most remunerative income and large dividends. To arrive at this successful result, however, the directors call upon the shareholders to rally round them, and not only to support them in the difficult enterprise in which they are engaged, but to use their influence in every direction to increase the number of subscribers of the Company, bearing in mind that every additional subscriber often carries with him a number of others, and that when the lines are once established and the exchanges are opened additional subscribers means additional profit at a comparatively small additional expense.

Mr. Robert Ewing seconded the motion.

Mr. Jackson inquired why the meeting was held on the 4th of July, seeing that the accounts were made up so far back as the 31st of December?

The Chairman, in reply, stated that the Articles of Association of the Company provided for the accounts being made up to December 31. They would have been very willing to hold the meeting many weeks ago if they could have done so, and they had been very anxious to hold it in order to relieve the shareholders' minds of anxiety. Everything was going on very well.

The election as a director of Mr. Jocelyn T. F. Otway was afterwards confirmed, and the auditors—Messrs. Chatteris, Nichols, and Chatteris—were re-elected.

THE BRUSH ELECTRIC LIGHT AND POWER COMPANY OF SCOTLAND (LIMITED).

An extraordinary general meeting of this Company was held at St. Michael's Hall, George-yard, Lombard-street, on the 5th inst., for the purpose of considering, and, if deemed desirable, passing the subjoined resolutions:—

1. "That the capital of the Company be reduced from £300,000, divided into 60,000 shares of £5 each (of which a first issue of 8,000 shares of £5 each, fully paid, and 22,000 shares of £5 each, with £2 10s. called up thereon, has been made), to £245,000, divided into 38,000 of £5 each, and 22,000 shares of £2 10s. each, and that such reduction be effected by reducing the liability upon each of the 22,000 shares by the sum of £2 10s., being the amount uncalled thereon."

2. "That the 8,000 shares of £5 each be sub-divided into 16,000 shares of £2 10s. each."

3. "That the 30,000 shares of £5 each at present unissued be sub-divided into 60,000 shares of £2 10s. each."

The Earl of Crawford and Balcarres presided.

The Secretary (Mr. Frederick M. Brocklebank) read the notice convening the meeting.

The Chairman referred to the legislation in connection with the electric light, and stated that the action of the Government in taking up the Electric Lighting Bill had, in his opinion, placed hampering conditions on what was going to be a most flourishing trade in this country. When he last addressed them they had applied for provisional orders for starting work in the four principal towns of Scotland—Glasgow, Edinburgh, Aberdeen, and Dundee. The requirements of the Board of Trade were peculiar, requiring a coalition, as it were, between the companies and the municipal authorities before anything could be done, and before the Board of Trade would issue what was called a provisional order. With the utmost efforts on the part of the directors, they had not been able to meet the requirements of the municipal authorities of Glasgow, Edinburgh, or Aberdeen; and it was their duty not to acquiesce in terms which would have made it impossible for them to work at a profit. After excessive trouble, they had been able to obtain from the Board of Trade the Dundee Lighting Act, and

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they hoped to proceed immediately with this provisional order. They considered they ought to be able to make a good thing out of it. They would lose no opportunity of trying to push the matter as far as they could in connection with private enterprise. They had decided to submit the resolution before them at the instance of shareholders. The directors had ample funds for carrying out the work before them. No further provisional orders could be obtained this year; but they had given notice of their intention to apply next year for provisional orders for no less than fifteen towns in Scotland. He concluded by moving the first resolution.

The Hon. ASHLEY PONSONBY seconded the motion, and expressed his belief that if the gas companies had had anything like the trouble and annoyance which the electric lighting companies had, there would have been no gas-lighting yet, but only oil and tallow candles.

The MANAGING DIRECTOR (Mr. Dickson), in reply to questions, said the provisional order for Dundee was for fifteen years.

The Hon. A. PONSONBY added that the order enabled the company to enter into a contract with the Dundee authorities, but there was no contract yet.

The SOLICITOR stated, in further reply, that he could not anticipate that there could be the least objection legally to the resolutions.

The CHAIRMAN put the motion, and declared it carried by more than a three-fourths majority; and, after some further discussion, the other resolutions were also passed.

THE EASTERN TELEGRAPH COMPANY, LIMITED.

Report of the directors for the half year ended 31st March, 1883, to be presented to the twenty-second half-yearly ordinary general meeting, to be held at the City Terminus Hotel, Cannon-street, in the City of London, on the 12th day of July, 1883, at one o'clock:—

The directors submit the accounts and balance-sheet for the six months ended 31st March, 1883. The Company's revenue for this period amounted to £328,404 14s. 11d., from which are deducted £87,827 1s. 10d. for the ordinary expenses, and £50,901 6s. 3d. for expenditure relating to repairs of cables, &c., during the half year. After providing £1,943 14s. 3d. for income-tax there remains a balance of £187,732 12s. 7d., to which is added £56,836 7s. 6d. brought from the preceding half year, making a total of £244,569 0s. 1d. From this amount there is deducted £22,479 16s. 8d. for interest on debentures, £20,297 4s. 5d. for dividend to 31st March, 1883, on the preference shares, and £85,000 placed to the general reserve fund, leaving a balance of £116,791 19s. The directors have during the half year paid an interim dividend of 2s. 6d. per share on the ordinary shares for the quarter ending December, 1882. They now recommend the declaration of a final dividend for the year ended 31st March, 1883, of 2s. 6d. per share, and a bonus of 1s. per share, both payable on the 14th inst., making, with the three previous payments on account, a total distribution of 12s. per share, or 6 per cent. for the year on the ordinary shares. The balance of £2,791 19s. shown at the foot of the revenue account is proposed to be carried forward to the next half year. The general reserve fund, after adding the interest received during the half year, now amounts to £537,889 10s. 5d.; this, with the special reserves stated on the balance-sheet, makes the total amount of reserves £569,823 0s. 6d. The revenue includes £14,479 12s. 1d. net receipts for the half year upon the company's shares in the Eastern and South African Telegraph Company. The reserve funds of that company now amount to £155,520 4s. 5d., and in addition the sum of £54,220 16s. 8d. is held by the trustees of the sinking fund for redemption of debentures. The revenue account also includes £2,600 dividend for the half year on the shares of the Black Sea Telegraph Company belonging to this Company, by which the line is worked and maintained under agreement. The various sections of the Company's cables are in good working order, and the Company's repairing ships are in efficient condition. The sum of £10,000 has been taken from the ships' maintenance fund in part payment for the ss. "Volta," as intimated in the last report. The whole cost of this vessel and outfit will be charged to the depreciation fund. The new vessel has already proved herself both economical and efficient. The triplicate cable between Suez and Aden, referred to in the last report, was successfully laid by the Telegraph Construction and Maintenance Company on the 21st of April last. The new line is working satisfactorily. In accordance with the agreement entered into with the Suez Canal Company, reported to the last meeting, the land line connecting the Company's cables at Port Said and Suez has been completed and is now in full work. In pursuance of the special resolutions passed last year, the directors have decided to issue £500,000 Four per Cent. Mortgage Debenture Stock for redemption of debentures falling due in October next, and other capital purposes for which the stock was authorised. As the Company's debenture stock constitutes a first charge upon the entire undertaking and revenue, the directors confidently recommend it as an investment.

COMPANIES' SHARE LIST.

TELEGRAPHS.

COMPANIES.	CLOSING PRICES JULY 4.		BUSINESS DONE WEEK ENDING JULY 4. Highest.	Lowest.
Anglo American	49,	50	50	49½
Do. Preferred	81,	82	82	81½
Do. Deferred	18½,	19½	19	18½
Brazil Submarine	11¼,	11¾	11 13-16	11⅜
Cuba	10½,	11	10½	10½
Do. Preference	17½,	18½	—	—
Direct Spanish	5½,	5¾	—	—
Do. Preference	15½,	16	—	—
Direct United States Cable	12½,	12¾	12 13-16	12½
Eastern Telegraph	10¾,	11	10 15-16	10¾
Do. 6 per Cent. Preference	13,	13½	13	13
Do. 5 per Cent. Debentures, 1899	104,	107	—	—
Eastern Extension	11¼,	11¾	11½	11 11-16
German Union	10,	10½	—	—
Globe Telegraph and Trust Company.	7½,	7¾	7¾	7½
Do. Preference	12¾,	13	13	12 13-16
Great Northern	12¾,	12¾	12 11-16	12 11-16
Indo-European	31½,	32½	31½	31½
Mediterranean Extension	1½,	2	1¾	1¾
Do. Preference	5½,	6½	—	—
Reuter's	9½,	10	—	—
Submarine	247,	252	—	—
West India and Panama	1,	1¼	1 1-16	1 1-16
Do. 1st Preference	6½,	7	6 11-16	6 11-16
Western Brazilian	5¼,	6½	—	—
West. Union 7 per Cent. 1st Mortgage	122,	124	123½	123½
Do. 6 per Cent. Sterling Bonds	103,	106	—	—

TELEPHONES.

Consol. Telephone and Maintenance	¾,	¾	—	—
Oriental	¼,	¾	¼	7-16
United Telephone	9½,	10	10	9¾

ELECTRIC LIGHT.

Anglo-American Brush Lgt. (£7 paid).	4,	4½	4 7-16	3¾
Do. (fully paid)	7,	8	7½	7½
Hammond Light	3½,	4	4 5-16	3½
Swan	2¼,	2½	2½	1 13-16
Maxim-Weston	¼,	¾	—	—

MISCELLANEOUS.

Telegraph Construction	33½,	34½	34½	33¾
India Rubber, Gutta Percha, and Telegraph Works	30½,	31½	31½	31½

A TELEGRAPH ENGINEER will shortly require a RE-ENGAGEMENT as MANAGER of Cable and General Insulated Wire Works. Gutta Percha and India Rubber Core; Military, Torpedo, Electric Light Cables and Leads; I.R. Cut Sheets, &c.; G.P. Surgical and other Sheets, &c.; Spreading. Sixteen years' experience in principal firms. Can provide complete instructing staff, mechanical and electrical. Terms inclusive. Any part of Europe. Address, in first instance,
"G. P.," care of Harding, Cocks, and Co.,
29, Jewry-street, Fenchurch-street, London.

A GOOD SECOND-HAND DYNAMO MACHINE REQUIRED. State full particulars, with price, to C. E. C., 110, Cannon-street, E.C.

WANTED, TWO or THREE (or more) GERMAN WORKMEN or STUDENTS to join with advertiser in any part of London in READING DYNAMO MACHINE LITERATURE. No expenses.—Address J. W., 21, Herbert-street, New North-road, N.

WANTED.—Volumes VII., VIII., and IX. of "THE ELECTRICIAN." State cash price and condition to RENNICK, KEMSLEY & Co., 4, Finsbury-circus, London.

DYNAMO, lights six 15 c.-p. Swan Lamps, £8. Larger sizes made. Experiments conducted for inventors. OPPERMANN BROS., Electric Light Engineers, Brewhouse-yard, 172, St. John's-street, E.C.

CARBONS.—For all kinds of ELECTRIC LIGHT,
Leclanché, Bunsen, and Grenet Batteries,
Telephones, &c.
The best, cheapest, and most reliable for every kind of Lamp.
Carbons of any size, shape, and of every description manufactured to order at the shortest notice.
JAMES W. COLUMBINE,
2, Carlisle-street, Soho-square, W.

TENDERS WANTED to SUPPLY the ARC LIGHT
for ST. JAMES'S HALL, BURNLEY.
Gas engine and about 40 Lights.
To be sent to THOS. BELL, Architect, Burnley.

TURKISH PATENTS.
NOTICE TO PATENT AGENTS AND INVENTORS.
The undersigned having established a special agency in Constantinople, are prepared to SECURE PATENTS in TURKEY for all inventions not yet in use in that country for £35, including drawings of average amount.
Special terms to Patent Agents.
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FAURE-SELLON-VOLCKMAR ACCUMULATORS.
On and after 1st January, 1883,
THE
ELECTRICAL POWER STORAGE COMPANY
(Limited),
4, Great Winchester-street Buildings, E.C.,
will be prepared to supply
FAURE-SELLON-VOLCKMAR ACCUMULATORS.
Which can be used in conjunction with any Incandescent Lamp or Electrical system, and afford the only reliable and economical means of Lighting Private Houses, Hotels, Theatres, Ships, Railway Carriages, &c., by Electricity.
Particulars and prices post free on application.

INSULATED ELECTRICAL WIRE, Silk, Cotton, or India-rubber covered. Conductivity guaranteed. German Silver Wires for Resistance. Braided Handle Cord, Silk Cord for Electric Bells, &c.—WILLIAM RICKARD, Derby London Agent (stock kept), EDWIN HOLLOWAY, 2, Gutter-lane, E.C.

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NOTES.

THE EASTERN EXTENSION COMPANY.—The Eastern Extension Telegraph Company notify that their Madras Penang cable is now repaired.

ELECTRIC RAILWAY AT BRIGHTON.—At Thursday's meeting in last week of the Town Council sanction was given to erect temporarily a short electric railway on the beach.

SOUTH KENSINGTON MUSEUM.—The directors of the Electric "Sun" Lamp and Power Company have undertaken to light the galleries at the South Kensington Museum by the "Sun" Lamp.

THE NEW PRESIDENT OF THE ROYAL SOCIETY.—At the meeting of the Council of the Royal Society on Thursday week Professor Huxley was chosen president in place of the late Mr. Spottiswoode.

ELECTRICAL EXHIBITION AT VIENNA.—Lord Sudeley, Sir William Thomson, Sir William Siemens, and Sir F. Abel, C.B., have been appointed British Commissioners for the Electrical Exhibition to be held at Vienna in August.

OPTICAL TELEGRAPHY.—M. Adam is endeavouring to establish a system of optical telegraphy between the islands of Réunion and Maurice, a distance of 245 kilometres. His preliminary experiments have proved satisfactory.

THE EASTERN TELEGRAPH COMPANY.—The Eastern Telegraph Company notify the repair of the Zanzibar-Mozambique cable, thus restoring telegraph communication with the East Coast of Africa and the Cape of Good Hope.

TELEGRAPH LEARNERS.—We understand that at the preliminary examination for male telegraph candidates which took place a fortnight ago before the Civil Service Commissioners about thirteen hundred applicants presented themselves.

THE WESTERN AND BRAZILIAN TELEGRAPH COMPANY.—The traffic receipts for the week ending 6th July, 1883, were £1,870, after deducting the "fifth" of the gross receipts payable to the London Platino-Brazilian Telegraph Company.

ELECTRICAL ACCUMULATORS.—According to *L'Electricité* Messrs. M. J. Arnould and B. Tamine have invented a new accumulator, the performance of which is said to be very remarkable, but the particulars of its construction are not yet made public.

ELECTRIC LIGHTING OF THEATRES.—The Theatre Gymnase, in Paris, will be lighted by electricity on the 1st September; the work of installation has already commenced, and is framed on the model of the system adopted in some English theatres.

ROYAL AGRICULTURAL SHOW.—We understand that the grounds at York will be illuminated by nine Crompton arc lamps of from 4,000 to 6,000 candle-power, the lamps being supplied by current from a Bürgin dynamo, driven by a Marshall and Sons engine.

THE EASTERN EXTENSION TELEGRAPH COMPANY.—The traffic receipts of the Eastern Extension Australasia and China Telegraph Company for the month of June, 1883, amounted to £34,307, and to £31,122 for the corresponding period of 1882; increase, £3,185.

A STEP BACKWARDS.—The Moor Iron Works Company, of Stockton, after a three years' trial of the electric light, have, it is stated, abandoned this system of illumination, and have resorted to the old mode of lighting by gas. The change has been made for purely economical reasons.

A SELENIUM REGULATOR.—The property which selenium possesses of conducting electricity more readily when in a bright light than when in comparative darkness has been turned to account by Signor Thommasi in constructing a regulator for the Jablochkoff candles, by which the point of luminosity is kept at a uniform intensity.

UNITED TELEPHONE COMPANY.—This company announces a dividend of 6 per cent. per annum for the year ending 30th April last. The directors resolved to recommend to the shareholders at the annual meeting, to be held on the 24th inst., the issue to the shareholders, *pro rata* to their respective holdings, of the remaining 20,000 £5 shares at £2 per share premium.

THE DYNAMICABLES.—On Friday, July 6, this social society met to dine at the Fisheries Exhibition, under the presidency of Professor W. G. Adams. There was a comparatively large gathering, and after dinner the exhibition was visited, not only by the members, but by lady and other friends who had been invited. Some grumbling was heard at the arrangement which necessitated the leaving of ladies to their own resources for a couple of hours or so while the members were at dinner. Is there an insuperable difficulty in such cases in inviting ladies to dinner?

ELECTRIC LIGHTING AT THE WEST END.—The Marquis of Salisbury's town residence, Arlington-street, is now lighted by Swan lamps. A 16 horse-power Otto gas engine has been fixed in the courtyard and drives a Siemens single current shunt wound dynamo machine, which produces sufficient current to maintain upwards of 300 Swan 100 volts 20 candle-power lamps. These have been arranged in parallel circuit on the present beautiful gilt candelabra, with the best possible effect. The work has been carried out by Mr. Shillito, the marquis's engineer, by whom the whole of the fittings have been designed.

ELECTRIC ALARUMS.—The *Novoe Vremya* states:—"A Russian inventor, the State Councillor of Kratkow, has just proposed to the Ministry of Finances the introduction of an apparatus which he calls the 'Electrical Guardian.' These instruments consist of electric conductors, connecting the safes of strong rooms to a strong alarm bell. The slightest interference with the safe puts the apparatus in motion and gives the alarm. By a recent improvement of the inventor this apparatus is made to sound the alarm in case the cashier forget to lock the safe. The price of this apparatus, including erection, fittings, &c., does not exceed 500 roubles (£50).

PARLIAMENT AND THE ELECTRIC LIGHTING ACT.—Commenting on the decision of the House permitting petitions to be lodged in Committee against provisional orders, *The Times* says:—"The enlargement of the reference to the Select Committee on which the House of Commons yesterday insisted is justified, perhaps, by the exceptional circumstances of the case, since where all is so novel and uncertain it is as well not to be tied down too strictly by technical rules adapted to more ordinary conditions. But it undoubtedly establishes a precedent which may be dangerous if loosely applied, and though it may justify itself in the end, it is only too likely to retard for a time the progress of public electric lighting."

ELECTRIC RESISTANCE OF PSILOMELANE.—Meyer's experiments with thin plates of psilomelane agree so far with those of Braun in demonstrating that such plates exhibit a remarkable unipolar conductivity. He shows that the resistance in one direction to that in the second direction is dependent on the intensity of the current, for on changing the

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latter the position of unipolar conductivity can be reversed. In other experiments with different plates it was found that the resistance was independent of the direction, continuance, and intensity of the current. No explanation is given as to the causes of the difference of action in the specimens. Meyer's experiments with pyrites and galena accord with those of Dupel, but not with those of Braun.

The Eastern Telegraph Company.—This company is now issuing 4 per cent. Mortgage Debenture stock, to the amount of £500,000, at £95 per £100 stock. From the advertisement which appeared in our last it will be seen that the principal objects of this issue are the redemption of terminable debentures falling due next October, and to pay for the Trieste-Corfu cable. The shares of the company are now at a premium, and during the past three years its dividends and bonuses have been at the rate of 5½ and 6 per cent. The reserve fund also amounts to £569,828, of which £328,574 is invested in securities. Applications for shares of the present issue should be made to Messrs. Glyn, Mills, Currie, and Co., 67, Lombard-street, London, accompanied by a deposit of 5 per cent. per share applied for.

The Director-General of Russian Telegraphs at Odessa.—Major-General de Bezack, the Russian Minister of Telegraphs, and successor of the late General von Lüders, visited Odessa on July 3, on a tour of inspection. His Excellency was received on board the steamer from Nicolaieff by the departmental authorities of the city and district of Odessa and Cherson, and by Messrs. F. H. Billows and J. Heyl, representing respectively the Indo-European and Eastern Black Sea Cable Companies. His Excellency, with a numerous suite, next day made a minute and lengthened inspection of the stations and traffic routine of the two English companies, and expressed himself highly satisfied with all he saw. The Director-General goes from Odessa southwards, *viâ* Kieff, in order to be present at the forthcoming Electrical Exhibition at Vienna.

Zinc Coating for Iron.—Attention has recently again been drawn (says the *Scientific American*) to MM. Neugean and Delaite's process of protecting iron surfaces against rust. A very fine powder of metallic zinc is mixed with oil and a siccative, and applied to the iron by means of an ordinary brush. In many cases one coat is sufficient. Two coats are at any rate guaranteed to secure a protection against the corrosive action of the atmosphere as well as of sea water. The zinc coating gives the iron a steel gray appearance, and it does not interfere with subsequent painting. MM. Neugean and Delaite received a diploma at the Paris Electric Exhibition of 1881, and now recommend their process for iron structures, bridges, lamp posts, &c., and also for iron ships. If this process really affords the protection it claims, nothing need be said in recommendation of it, since it can hardly be surpassed in simplicity and cheapness, and is capable of application in cases where galvanising, the Bower-Barff and similar processes, would hardly be practicable. A good mixture, of which only the necessary quantity ought to be prepared, consists of eight parts by weight of zinc, 71 of oil, and two of a siccative.

Electrical Torpedoes in the Potomac.—Two torpedoes have been taken out of the Potomac river, at Washington, from the channel near the mouth of the branch, by the boatman on the large Government dredge which has been dredging the channel. The first one was found about six weeks ago, the other on the 16th. The first was taken to the ordnance machine shop, emptied of the powder, cleaned and examined. The second is made of light boiler iron, in the shape of a cylinder, about three and a half feet in diameter and about the same in length. It contained about two barrels of coarse gunpowder, which was fortunately wet at the time it was scooped in. The copper wire attachments to be connected with an electrical battery to explode it are still intact. There are two small holes in the iron, caused by rust. After taking the first one out and discovering that it was full of wet powder, the workmen were very particular about how they handled the second until they were satisfied that the powder in it was also wet. Had either of them been made of copper they would have been thoroughly dry inside, and as the scoop made a large indentation in the sides of them, they might have exploded and blown up the vessel and all on board.—*Electrical World.*

Exhibition of Electric Lighting.—At a meeting of the Mining Institute of Scotland, which was held in the Christian Institute, Bothwell-street, on Thursday, July 5, Mr. James M'Raith in the chair, the discussion on Mr. Connell's paper was resumed. The subject was "Spontaneous Combustion of Coal in Ships." Having accepted an invitation from the Edison Electric Light Company, the members of the institute on the conclusion of their discussion visited the office in West Nile-street, and were shown the Edison lamps in use. The members were afterwards entertained to an exhibition of the different systems of electric lighting and apparatus by Messrs. Norman and Son, engineers, Argyll-street. The company was received by Mr. Musgrove, the senior partner of the firm, who introduced Mr. M'Whirter, the manager. The latter gentleman explained the various processes and different systems of electric lighting. He first gave an exhibition of the working of the Crabbe lamp, which he said is a modification of the Crompton light. The latest improvement on the Crompton lamp next engaged the attention of the company. Mr. M'Whirter explained that whereas this lamp at first only burned for about five hours, it now, by altering the arrangement, burned for 12 or 13 hours without a change of carbon.

Sixpenny Telegrams.—On Thursday, 5th inst., Mr. Fawcett, in reply to Mr. Puleston, said that the Government had decided not to come to any decision with regard to the particular form of introducing the sixpenny telegram until next Session. There would be then no objection to give, as far as possible, the financial results that might be anticipated from any of the three plans mentioned in the Treasury minute. In answer to Mr. Alderman Lawrence, Mr. Fawcett said it was, no doubt, the case that, under Schemes 1 and 2, it would be possible, under certain circumstances, that a higher charge would be made for telegrams of twenty words than at present, but he could not agree with his hon. friend that there would be few telegrams for sixpence. On the contrary, he thought that under either of these schemes a great number would be sent. As he stated the other day, no particular scheme would be adopted till next Session. If any change whatever was adopted, with regard either to free addresses or what would render it possible to charge more than 1s. for twenty words, it would be necessary to introduce a Bill.—Mr. Alderman Lawrence gave notice that he would move "That any scheme for reducing the minimum charge for Post Office telegrams to sixpence should recognise the fact that much longer addresses are required by artisans and small traders than by merchants and bankers."

Dry Batteries as Accumulators.—Herren J. Elster and H. Geitel have recently been making experiments in this direction. Between the conductors of a Holtz machine they interposed a Zamboni dry battery consisting of 11,000 elements of one square centimetre in section. The copper pole touched the positive conductor of the machine, the negative conductor being in connection with the other pole. After 10

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minutes' interval the E.M.F. of the battery had so far increased that a spark was produced between its poles when they were at one millimetre distance. The battery, polarised in this way, caused continuous action in a small Geissler tube. This led Messrs. Elster and Geitel to endeavour to construct a secondary battery with one metal only, taking as their model the Planté battery. On each face of a leaf of lead paper they pasted a leaf of tissue paper impregnated with a solution of silicate of potash, having a little oxide of lead added to it. They divided the whole up into little discs of one square centimetre, which they piled the one on the other to the number of 7,000. Treated like the Zamboni battery, this latter gave slightly greater results. If, in place of forming the battery electrically, it is constructed with binoxide of lead ready formed, the effects obtained are less strong. The experimenters consider these dry batteries as very effective for showing to a large audience the principle upon which accumulators work.

The Chelsea Vestry and Electric Lighting.—At the last week's meeting of the Metropolitan Board of Works Mr. R. Cox introduced a deputation from the vestry of Chelsea, who presented a memorial, calling attention to some of the allegations in the Board's petition against the Electric Lighting Provisional Orders Bill for confirming provisional orders relating to Chelsea and Greenwich, and asking the Board to reconsider the question whether it is advisable to follow up the said allegations. The memorialists stated that they had learned with much surprise and regret that this Board had presented a petition against the Electric Lighting Provisional Orders Confirmation Bill in so far as it affected the parish of Chelsea. They viewed with grave concern this step taken by the Board inasmuch as if persisted in its probable effect would be to prevent the passing during the present Session of the said Bill, and so to defer the introduction of electric lighting into the parish of Chelsea for at least two years. The memorialists were of opinion that the establishment and exercise of a divided responsibility and authority had generally a mischievous tendency, and were productive of unseemly litigation and conflict between public bodies. They therefore prayed that the Board would see fit either to withdraw the said petition, or so to amend the same that all reference to the parish of Chelsea might be excluded therefrom. After some discussion the memorial was referred to the Board's Parliamentary Committee.

Preparation of Carbons for Electric Lighting.—M. Jacquelain has endeavoured to prepare carbon of like density and conducting power to gas-carbon and without its impurities. He removes impurities by three processes: (1) Treatment with dry chlorine at a red heat for thirty hours to remove silica, metallic oxides, and hydrogen. (2) Treatment with fused potash or soda. The alkali must not be too strong nor the temperature too high; Na_2O, with three equivalents of water answers well. An immersion of three hours is generally sufficient, after which the carbon is washed with water, then with dilute hydrochloric acid, and again with water. (3) Immersion in hydrofluoric acid diluted with twice its weight of water from twenty-four to forty-eight hours at a temperature of 15° to 25°. The gas carbon may be submitted to either of these processes after being cut into pencils. To restore the carbons to their original density they are carbonised by being strongly heated for a few hours in the vapour of some heavy hydrocarbon. Pure graphitoid carbon may be prepared directly by passing the vapour of some heavy hydrocarbon through a fire-clay tube raised to a temperature of 1,000° to 1,200° C. Hydrocarbons with high boiling points answer best, and gas tar is the most suitable for use on a commercial scale. The steadiness of the light and durability of the carbons are in direct proportion to their hardness, density, and purity. The best results in experiments have been obtained with Siberian graphite (sp. gr. 2·3, gas carbon being 1·9) purified by treatment with hydrofluoric acid, by which process the percentage of ash was reduced from 8·674 and 5·184 to 0·767 and 0·900.

Electric Lighting Provisional Order Bills.—In the discussion in the House of Commons on Thursday, the 5th inst., relating to this subject, Mr. Chamberlain stated that he had not understood that the fact of the substitution of a hybrid committee for a Select Committee was to have any effect upon the *locus standi* of petitioners. The Electric Lighting Act made the vestry the local authority, and the vestry of St. James's had assented to the order applied for by the Edison Company. The Telegraph Construction Company had now come forward with a proposal to light the district at a maximum price 40 per cent. below the maximum offered by the Edison Company. That was an *ex parte* statement, and if an order were granted upon it what was there to prevent another company from coming forward and asking them to go all through the matter again because it offered a maximum 5 per cent. cheaper than that of the Telegraph Construction Company. In this way they might go on as long as there were any promoters, speculative or otherwise, offering to do the work more cheaply. It must be remembered that in fixing a maximum a margin was allowed above the price at which the competition of gas companies would cause the light to be supplied, and therefore it did not follow that the public would obtain an advantage from a lower maximum. It seemed to be assumed that the inhabitants were to be bound to a monopoly for twenty-one years, but all that was done by an order was to give a company power to take up the streets and lay down wires, and the companies were distinctly informed that they were not granted a monopoly. The Telegraph Construction Company could, therefore, if it could show that it was able to supply light more cheaply, apply for and obtain a competing order. When the inhabitants of a district were represented by their local authorities it was not usual to allow the inhabitants themselves a *locus standi*, and in this case the vestry of St. James's had been heard. After some discussion, however, Mr. Chamberlain yielded to the opinion of the House that petitions against the Bill be allowed and referred to a Select Committee.

The Telephone and Induction.—The experiments of Herz and Rysselberghe prove that telephonic communication is possible over lines of considerable length, though the practical solution is not yet attained, due probably to the unsuitability of the instruments hitherto used. It is found, for instance, that though the thin steel diaphragm of the American type of telephone speaks with clearer articulation on short lines, that on longer ones the thicker plate of the Siemens form gives far better results. Dr. V. Wietlisbach theoretically determined the maximum distance over which such communication is possible, considering the limiting effect of the nature of the conductor in the first place, and, secondly, the interference of neighbouring lines. On the first point the rate of transmission of electric waves is a function of the resistance and electrostatic capacity of the circuit, the increase in the product of these two quantities corresponding with diminution in amplitude and velocity of the wave. This retardation is also a function of the rate of vibration of the sound, so that if the assumption is made that each sound must have a duration of at least $\frac{1}{10}$ second, and a retardation of not more than $\frac{1}{100}$ second between the highest and lowest tones be allowed, the limiting distance for an underground

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cable similar to the type adopted by the German Government would be 1,300 kilometres (800 statute miles), about the distance between Berlin and Paris or Vienna. As the capacity on overhead lines is, however, considerably less, the limiting distance in their case would be much greater. On the second point distinction must be made between the disturbance resulting from electrostatic and electro-dynamic induction; the first can be prevented by enclosing the insulated conductor in a metallic sheath, as has already been done. The second is, however, not easily prevented. It can theoretically be overcome in certain cases by increasing the resistance of the receiving instrument to a value considerably exceeding that of the lines, but as this also reduces the sensitiveness of the sending instrument, and the dimensions would so rapidly increase with the length of the line, this method is not practicable. On short lines, Professor Hughes's induction balance might be applied, but this again exceeds the limits of practicability for more than two or three parallel lines. The only real way out of the difficulty is the use of a metallic return circuit entwined with the original conductor, so that the induced currents are balanced on the two parts of the circuit. The especial difficulty in any other solution of this problem is that the induced currents are more powerful than those excited by the microphonic sender; hence the numerous proposals for increasing the action of the latter.

International Electrical Exhibition, Vienna, 1883.—For some weeks the preparations for the International Electrical Exhibition have conjured a gay and stirring life in the vast rooms of the Rotunda, at other times so quiet, which must interest every visitor on account of the great contrast with the intense quietness of the surrounding greens of the Prater. From early morn till late at night echo through the vast exhibition rooms the sounds of different works; here the monotonous song of the pile drivers, there the planing, sawing, and boring of the lumberers, yonder the creaking of the carts, conveying building materials, or the jarring of the wheel-barrows, removing the clay, and everywhere the knocking and hammering of electricians, drawing on high ladders a whole net of conducting wires through all rooms of the Rotunda, or clearing the way for them underground. Many of these industrious men will not even have the satisfaction of seeing the results of their eager labour duly admired, for many and not the least of these works will entirely withdraw from sight, as they are laid under the floor, or hidden somewhere else. Thus particularly the part of the mason and building works, which we will especially speak about to-day. While those works of the theatre, the two restaurants, the interiors, the different pavilions, the telephone rooms, and the reading hall are being surveyed by the architect, Alexander Décsey, who has made the designs for these objects, the foundations of the steam engines and dynamo machines, and its transmissions, as well as the disposition, foundation, and setting of the boilers, are being executed according to the designs of the engineer, Professor Tosef Pechan, and under the management of the engineer, Wilhelm Fletinsky, and carried out by the contractors, Messrs. Frauenfeld and Berghof. Adjacent to the large chimney mentioned in former reports, for which 700 cubic metres of brick masonry have been employed, will be the boiler shed, with two wings, built in right angles of 64 metres in length each. The latter will be connected with the machine hall by covered passages, and will cover a space of 2,250 square metres. The whole earth-work in the galleries and the boiler-shed amounts to about 2,000 cubic metres, and in masonry work fall out for the boiler-house and flues 250 cubic metres, for the foundations of 14 stationary boilers 150 cubic metres, for the foundations of 22 portable steam motors 150 cubic metres, for the foundations of stationary engines and 8 gas engines with round 1,200 horse-power for driving the dynamo machines, 1,200 cubic metres for the foundations of the transmissions, dynamo machines, and different other arrangements about 900 cubic metres. All in all, therefore, about 3,350 cubic metres of masonry, the entire completion of which will take place within a few days. In the meantime begin the consignments of exhibits from all parts of the globe, and the places will soon be occupied by boilers, machines, and other objects.—*Communicated.*

Mr. Edison's Opinion of Electricity as a Motor.—Mr. Edison was questioned recently as to the feasibility of running trains by electricity on the regular railroads. The *Electrical World* quotes Mr. Edison's remarks, but does not give its authority:—" The manner in which it is proposed to operate the railroads by electricity," he said, "is by means of a central rail laid between the existing tracks, for which old and worn-out rails might be used, this rail acting as one pole and the other two forming the other. The power would be transmitted by a central engine with the use of powerful dynamos, and the electricity would thus be supplied to the rail, from which it would be taken up by the motor attached to a train where there are two or more cars attached. In the case of street surface the motor could be carried underneath, and would not necessitate an extra carriage for a motor engine. The whole operation would be similar to the endless rope by which cars are drawn along in Chicago and other cities. The method of stopping would be by means of a 'clutch,' whereby the electric power would be thrown out of gear so far as it operates on the drawing or driving power of the motor, while at the same time the current would still be kept operating on the motor so that a start could be effected at a minimum loss of power, similar to the shifting of a belt on a shafting." The advantage he claims for the new invention is that it will effect a saving of 33 per cent. in the amount paid for coal under the present system of steam locomotives. There would also be a slight saving in the matter of the wear and tear of the two different styles of engines or motors. "For the present," continued Mr. Edison, "I do not think that electricity will be generally adopted for heavy freight trains or for passenger trains over long distances, but for street cars, elevated railroads, and other short lines it will be found invaluable. Already we have applications for the use of our patents from Coney Island, Long Branch, Fairmount Park, Saratoga, and from the elevated railroads in New York. In the case of the latter it will effect not only a saving of 33 per cent. in the matter of coal, but it will also do away with one man on each engine, and further save the annoyance now experienced in the matter of the shower of sparks and the smell of sulphur which is so objectionable." The exact form the motor attached to a train would take he could not, he said, at present give, but he believed it would take one of the shapes of Mr. Field's patents. The matter of snow would be no impediment to the transmission of power, as a sort of a cow-catcher had been devised that would so come in contact with the central rail through which it would be transmitted that it would at all times and in the severest storm be entirely cleared off. Any rate of speed could be obtained, according to the power used at the central depots. When asked if he thought steam as a motive power would be eventually superseded by electricity, Mr. Edison said that he had no doubt such would be the case, but not for some years to come. Steam, he said, is now and will be essential to the generation of electricity, but he believed that means sooner or later will be found to obtain

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electricity from the earth without the use of any machinery whatever.

The Metal Trades Exhibition.—We briefly mentioned in our last issue that in this exhibition there would be found one or two exhibits of a distinctly electrical nature. Opposite the main entrance is the exhibit of Messrs. Felten and Guilleaume, whose agents in England are Messrs W. F. Dennis and Co. The firm owns two works, viz., the hemp-spinning mill "Rosenthal," in Cologne, and the wire, wire-rope, and telegraph-cable manufactory "Carlswerk," in Mulheim-on-the-Rhine. The Cologne works produce thread, twine, and hemp ropes at the rate of 2,500 tons per annum; they employ about 600 hands and engines of 500 horse-power. The Mulheim works embrace the wire-drawing mills, the very extensive galvanising shops, the wire ropery and the telegraph cable manufactory. The annual production amounts to about 30,000 tons, 1,200 hands are employed and engines of 750 horse-power. The value of the annual production of both works comes up to about £1,000,000 sterling. This firm was the first in Germany to manufacture galvanised telegraph wire, and in 1852 they made the first delivery of such wire to the then existing Prussian Telegraph Department. The year following they were the first on the Continent of Europe to commence manufacturing telegraph cables, and ever since they have been closely connected with the development of underground telegraphs, taking a deep interest and a very active part in the improvements of underground cables for that purpose. In 1875 Messrs. Felten and Guilleaume were called upon by the Prussian Government to make the first extensive underground telegraph line for a trial, viz., from Berlin to Halle, a distance of 170 kilometres. When this trial line had given every satisfaction, the postal authorities gave orders to proceed with the network of underground telegraph lines proposed for the whole of the German Empire. This system of underground lines, embracing about, 5,100 kilometres of cable, and altogether 38,000 kilometres of insulated conductors, has been completed, and this firm has manufactured and laid down the larger part of the above-mentioned system. They have supplied the galvanised sheathing wire for many of the large submarine cables which have been laid down for some years. It may here be mentioned that last year the manufacture of galvanised wire for sheathing cables as well as for overhead lines reached the extent of 15,000 tons, and that this year their supply of wire for the said purposes will exceed that figure. The manufactures which have no connection with electricity may be left unnoticed for the present, and we proceed to offer a few remarks with reference to the cables and wires, which are exhibited in a very handsome glass case. The middle compartment contains samples of wire ropes for aerial tramways, lightning conductors, ships' rigging, and steel hawsers; the right-hand one hemp rope, twine, &c.; the left-hand cables for field telegraphs and torpedoes, with various coverings. The electric conductor of nearly all the cables is composed of seven fine copper wires, made of the purest copper in order to keep the electrical resistance as low as possible. With the exception of a few special cases, where india rubber has been taken for some reason, the conducting wire is insulated by gutta percha, which surrounds the wire in several layers, and of a thickness to meet the requirements, as the case may be. The gutta percha is most carefully cleaned of all its impurities, all the air has been scrupulously expelled to prevent the formation of air-bubbles, and no trouble has been spared to obtain as dense and uniform a material as possible, so as to insure a perfect insulation of the wire. The hemp which is wrapped round the insulated wire, and which is to protect the latter against being injured by the sheathing wires, has been dipped in tar specially prepared for preventing the hemp from rotting without doing the gutta percha any injury. The size of the material and the material itself for the sheathing have been selected with due regard to the purpose the cable is to serve and the work it is expected to do. The final coating of compound which is to give the cable an air-tight jacket has not been put on some of the cables for the purpose of allowing the sheathing wire to be exposed to view. Field-telegraph and torpedo cables must be as light as possible, and they should also be very pliable, and yet able to resist a heavy breaking strain. For these reasons steel wire is used for sheathing such cables. To make them more pliable, strands of thin steel wire have been employed instead of solid sheathing wires; and to prevent the formation of kinks, which in laying out the cable so often cause the conductor to snap, one-half of the strands are laid with a right turn, the other strands being laid in the opposite direction. This arrangement of alternate laid sheathing strands is also a good safeguard against the cable becoming severed when attached to a swinging buoy. The same considerations have ruled the construction of the anchor-ropes for torpedoes and mines, of which a few samples are exhibited with the cables. The insulated and covered wires in the left hand compartment are for different purposes; some are insulated with gutta percha, others are not; some are covered with cotton yarn, others with prepared tape. For conducting powerful induced currents for electric lighting and other purposes the copper conductor is formed of a number of thin wires properly stranded, the whole of a metallic section proportionate to the strength of a current and to the distance of the place of application (for instance the lamp) from the source of electricity (the dynamo). This copper conductor is supplied with either a single or a double, or even a three-fold wrapping of prepared tape, which resists most effectually the destructive power of an induced current. In the centre of their stand is a fine pyramid rising to 15ft., composed of various qualities of wire, viz., galvanised patent steel wire, galvanised oiled steel, iron fencing wire, coppered and galvanised spring wire, telegraph wire, tinned wire, and annealed weaving wire. On the left a rather smaller pyramid of galvanised wire rope, &c. On the right are two smaller show cases containing some good samples of electric light wire, telephone wires, patent steel music wire (which they have lately commenced to manufacture), and submarine cables. At each end there is a fine collection of electric light conductors, also lead covered cables and telephone leading in wires. They also show a coil of patent cast-steel galvanised mooring rope for torpedoes, the strands alternately twisted to the right and left hand, composed of 6 strands, each 7 wires, and main hemp core; also a coil of patent cast-steel wire rope, the strands and rope both being twisted in the same direction, and composed of 6 strands, each 7 wires, and a main hemp core. The firm consider their patent cast-steel wire to be the best for telephone purposes, on account of its high breaking strain and great tenacity and elasticity, which are all very valuable qualities for telephone lines, where the supports are mostly placed at considerable distances apart. The patent cast-steel wire is made to any breaking strain up to 120 tons per square inch. With this patent wire the margin of elasticity very closely approaches the breaking strain, and thereby this wire is enabled to store the tension caused by the contraction in cold weather, and to yield it again without suffering an elongation when warmer weather sets in. These and other specimens make this exhibit worthy of attention.

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CURRENT ENERGY.—V.

BY OLIVER HEAVISIDE.

(CONTINUED FROM PAGE 150.)

When we apply Ohm's principle of the constancy of the resistance co-efficient in the most general manner possible to bodies which conduct differently in different directions, a remarkable consequence is the establishment of the possibility of existence of a *rotatory* resistance co-efficient, or rather of three co-efficients which specify a definite axis of rotation. Thus, in order to express without hypothesis the relations between E.M.F. and current at any point, we require no less than nine co-efficients of resistance, or an equal number of conductivity, viz., three direct and six transverse; a direct co-efficient referring to the current produced in a certain direction by an E.M.F. acting in that direction, and a pair of transverse co-efficients to express the component current in the plane perpendicular to the E.M.F. Taking x, y, z for any three rectangular axes of reference through the point considered, let an E.M.F. of strength X along x produce currents k_{11} X, k_{21} X, k_{31} X along x, y, and z respectively, these being the components of the actual current, and employ a similar notation for E.M.F.'s acting along y and z. Then, if any E.M.F. of strength E, whose components are X, Y, Z, produce a current C, whose components are u, v, w, we have the equations of conductivity,

$$u = k_{11}\,X + k_{12}\,Y + k_{13}\,Z;$$
$$v = k_{21}\,X + k_{22}\,Y + k_{23}\,Z;$$
$$w = k_{31}\,X + k_{32}\,Y + k_{33}\,Z;$$

where the k's are the nine co-efficients of conductivity, k_{11}, k_{22}, and k_{33} being direct, and the rest transverse. We have, of course, an exactly similar set of equations of resistance, expressing the E.M.F. in terms of the current, thus,

$$X = r_{11}\,u + r_{12}\,v + r_{13}\,w;$$
$$Y = r_{21}\,u + r_{22}\,v + r_{23}\,w;$$
$$Z = r_{31}\,u + r_{32}\,v + r_{33}\,w;$$

where the values of the r's, the co-efficients of resistance, may be put in terms of the k's by solving the former equations for X, Y, Z.

Now, these equations are of the same form as those concerned in the transformation of a sphere into an ellipsoid, exemplified in the theory of strains, and we may thus interpret them. Let the E.M.F. at the point considered be of constant strength, but variable in direction. Representing it by a straight line drawn from the point, the extremity of this line of E.M.F. will obviously travel over the surface of a sphere when we vary its direction. At the same time, the corresponding current will vary both in direction and strength, and if we represent it also by a straight line drawn from the centre of the sphere, then as the extremity of the line of E.M.F. travels over the spherical surface, that of the line of current will travel over the surface of an ellipsoid.

There is, therefore, in general, corresponding to an E.M.F. of constant strength, but variable direction, a direction of maximum current, one of minimum current, and a third minimax, corresponding to the three principal axes of the ellipsoid. Two axes may be equal, or all three, in which last case the ellipsoid becomes a sphere.

Similarly, let it be the current that is kept of constant strength whilst its direction varies, and represented by a straight line of constant length, whose extremity, therefore, travels over a spherical surface. Now it is the E.M.F. required to produce the current which varies in strength in different directions, and as the line of current travels over the spherical surface, that of E.M.F. travels over the surface of an ellipsoid. But this second ellipsoid has not in the general case its principal axes in the same direction as those of the first. For this to be the case there must be a certain symmetrical relation, which may be thus expressed. E_1 and E_2 being any two E.M.F.'s, and C_1 and C_2 the currents they produce, then we must have $\overline{E_1C_2} = \overline{E_2C_1}$, or in terms of components

$$X_1u_2 + Y_1v_2 + Z_1w_2 = X_2u_1 + Y_2v_1 + Z_2w_1.$$

The interpretation of $\overline{E_1C_2} = \overline{E_2C_1}$ is that an E.M.F. acting in any direction produces the same component current in any second direction, as the same E.M.F. acting in the second direction does in the first.

In a system of connected linear conductors the corresponding property is that the current produced in a branch R_2 by an E.M.F. in another branch R_1 equals the current in R_1 due to the same E.M.F. in R_2, with similarity of direction. That is, choosing the directions of E in R_1 and of C in R_2 as positive, when E is transferred to R_2, and acts in the assumed positive direction, C will be also in the assumed positive direction in R_1. This reciprocal property is necessary in a system of linear conductors; but there is nothing to prove that the corresponding law $\overline{E_1C_2} = \overline{E_2C_1}$ is necessary in a non-isotropic conductor. But, supposing it to exist, it follows that the transverse co-efficients are equal in three pairs; thus, $k_{12} = k_{21}$, &c., and $r_{12} = r_{21}$, &c. The principal axes of the two ellipsoids above mentioned are now coincident in direction, and if we choose them for our axes of reference (x y z), we reduce the general equations to the simpler forms

$u = k_1X$, $v = k_2Y$, $w = k_3Z$; and $X = r_1u$, $Y = r_2v$, $Z = r_3w$,

where the k's are the principal conductivities, and the r's the principal resistances, viz., along the common axes—and now, which was not the case before, the r's are the reciprocals of the k's.

From these equations we see at once that there are three lines of directional identity of the current and the E.M.F., viz., the three mutually perpendicular principal axes for which the current is maximum, minimum, or minimax, with an E.M.F. of variable direction but constant strength. In any other direction there is not coincidence, thus l, m, n, being the direction cosines of the E.M.F., those of the current are lk_1/k, mk_1/k, nk_1/k, where $k = \sqrt{l^2k_1^2 + m^2k_2^2 + n^2k_3^2}$; and the strength of current is $C = kE$.

If we describe an ellipsoid whose axes are along the principal axes, but of lengths proportional to the square roots of the principal resistances, and let the radius vector from the centre to any point of the surface represent the E.M.F. in magnitude and direction, the corresponding current will be parallel to the normal to the surface at the point, therefore along the perpendicular from the centre upon the tangent plane, and its strength will vary inversely as the length of the perpendicular. Similarly, with an ellipsoid whose axes are of lengths proportional to the square roots of the conductivities, the radius vector representing the current, the E.M.F. will be inversely as the perpendicular on the tangent plane and in its direction.

When this symmetry does not exist (k_{12} not $= k_{21}$, &c.), we have rotation. Representing the E.M.F.'s by radii of a sphere, the lines of current trace out an ellipsoid, as before, but we no longer have the lines of directional identity of current and E.M.F. for the principal axes of the ellipsoid, for the ellipsoid is rotated as a whole about a definite axis, besides altering somewhat in shape to become another ellipsoid. Similarly with the sphere for current, the ellipsoid for E.M.F. is rotated, though not about the same axis, save in a special case. There may be still three lines of parallelism of current and E.M.F., though no longer mutually perpendicular, nor coincident with the principal axis; but also there may be only *one* such direction. And this last case is the special case of identity of rotation axis of resistance and conductivity, and exhibits the rotatory phenomenon in the simplest form. Let a conductor be isotropic in the first place, $E = RC$, or in terms of the components $X = Ru$, $Y = Rv$, $Z = Rw$, where R is the one resistance co-efficient, and introduce rotation upon the top of this. We may put $r_{11} = r_{22} = r_{33} = R$ in the general equations, and $r_{23} = -r_{32} = T_1$, $r_{31} = -r_{13} = T_2$, $r_{12} = -r_{21} = T_3$; which in a system of linear conductors would imply exact reversal of the reciprocal property. We now have

$$X = Ru + X_1, \qquad Y = Rv + Y_1, \qquad Z = Rw + Z_1$$

where $X_1 = T_3v - T_2w$, $Y_1 = T_1w - T_3u$, $Z_1 = T_2u - T_1v$. Multiplying X_1, Y_1, Z_1 first by u_1, v_1, w_1 respectively and adding, and then the same with T_1, T_2, T_3, we find

$$X_1\,u + Y_1\,v + Z_1\,w = 0 \text{ and } X_1\,T_1 + Y_1\,T_2 + Z_1\,T_3 = 0.$$

Hence the E.M.F., say E, whose components are X_1, Y_1, Z_1,

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is perpendicular to the current C, and to a vector, say T, whose components are T_1, T_2, T_3. Also, if θ be the angle between T and C, we have $E_1 = TC \sin \theta$.

E is therefore resultant of two E.M.F.'s, one of strength RC in the direction of the current, the other of strength CT sin θ, perpendicular to C and to T. These three E.M.F.'s form the three sides of a right-angled triangle, of which E is the long side, whence, by the famous 47th, $E^2 = (RC)^2 + (TC \sin \theta)^2$, which gives $E = (R^2 + T^2 \sin^2 \theta)^{\frac{1}{2}} C$. Also, if ϕ be the angle between E and C, $\tan \phi = T/R$.

The one line of parallelism of current and E.M.F. is the axis of T, which indicates a definite direction in the body, independent of the directions of E or C. Put $\theta = 0$, and we have simply $E = RC$ when E acts along the axis of T. Next, let it act straight across the axis. Put $\theta = 90°$, then $E = (R^2 + T^2)^{\frac{1}{2}} C$, or the specific resistance is apparently increased from R to $(R^2 + T^2)^{\frac{1}{2}}$; but C and E are not parallel. C is still perpendicular to the axis, the same as E is, but is rotated through an angle ϕ, such that $\tan \phi = T/R$.

In the general case of E inclined at any angle to the rotation axis, the component of E along the axis produces current parallel to itself as ordinarily, and the component perpendicular to the axis current with resistance $(R^2 + T^2)^{\frac{1}{2}}$ and rotation ϕ. The sphere of E.M.F. becomes a prolate ellipsoid of revolution for the current, the long axis being parallel to T, and showing the one line (instead of three) of parallelism of C and E.

The necessity of nine co-efficients in the general case, and hence the possibility of existence of the rotatory effect, was maintained by Sir W. Thomson in 1854; Maxwell said there was reason to believe it did not exist in any known substance, but should be found, if anywhere, in magnets. Its actual existence was only demonstrated two or three years ago by Hall's discovery that it is developed in metals when placed in a powerful field of magnetic force.

Let there be a steady current in a straight isotropic wire, and for distinctness let it go from left to right in the plane of the paper, and be kept up by a battery. Now let the lines of force of a magnetic field pass straight through the paper, and therefore perpendicular to the current. Ignoring altogether the ordinary current of induction, examine what the effect of the rotatory resistance vector will be, assuming it to be parallel to the lines of force, say downwards through the paper. The current must be deflected in the plane of the paper, say from ⟶ ⟶ it tends to ↗ ↗. But this transverse current will alter the distribution of the surface charge, the upper half of the wire will receive a positive, and the lower a negative charge, independent of the original distribution. This will introduce a downward E.M.F. across the wire, tending to decrease the deflection. So long as any transverse current exists this opposing E.M.F. will increase; hence the final result is that it reaches such a value as to keep the current going straight from left to right as before the magnetic force was put on. Thus the deflection of the current can be but momentary; on its cessation the current goes on as before, but now under the influence of an impressed E.M.F. not in its direction, but from left to right with a downward slant, being the resultant of the original E.M.F. and of the transverse downward E.M.F., whose strength must be TC.

Two points of the wire, one above and the other below, which were originally at the same potential, are under the influence of the rotation made of different potentials, the upper being positive to the lower, and a current may be therefore taken off in a shunt wire between the two points. The difference of potential is, of course, greatly magnified by using a very thin sheet instead of a wire, and thus was rendered perceptible.

Before leaving Ohm's law solus and proceeding to conservation I cannot help unburdening myself of a conviction that has long been forcing itself on my mind with ever-increasing persistency. Ohm's law, although, singularly enough, its recognition was slow in the first place (for it is said that Ohm, who was a shy, retiring man, received the cold shoulder, and was shunted off into the obscurity of his garret with frozen grate), long ago became of immense practical importance, owing to the commercial value of the applications of electricity. But in the last few years its use has been multiplied enormously, through electric lights and one thing and another. In fact, for once it is used by the telegraph engineer it is used twenty times or more by an electric light man. Conceive, then, if you can, the electric light young man having to consult at every step volumes of tables and intricate formulæ to ascertain what current corresponded to a given E.M.F. in a given wire under given circumstances if its resistance were not, as it is, practically constant; if it were to vary, for instance, greatly with how long the current had been on, or with the E.M.F., or in innumerable other ways; for who shall say what might not have been? The electrician would be in a perpetual state of harassment, which would certainly tend to shorten his days though it lengthened his day's work. Now, is not this fitness of things as regards Ohm's law a powerful argument in favour of design? Can it be doubted that the constancy of R was providentially arranged to meet the requirements of man? I think this can only be contested by those wicked writers of dreary articles in monthly magazines whose pernicious stuff appears to be deliberately intended to undermine all our inherited faiths, and who seem determined to leave no place in the world for its own maker. At any rate, this argument in favour of a providence might be added (to keep it up to the times) as an appendix to the next edition of "Paley's Evidences," a work whose perusal I can cordially recommend to all who, having had their peace of mind destroyed by the scoffers, have a difficulty in getting to sleep at night. As for myself, I may add that such was its soothing and calming effect on the nerves that, like Ingoldsby's shirt that never was new, it was often begun but never got through.

NOTE ON MANCE'S BATTERY TEST.

BY E. RAYMOND BARKER.

This test consists in adjusting *a*, *b*, and R, until the deflection D of the galvanometer G remains constant, whether the key K be open or closed. Should R be adjusted to a resistance higher than that of B, D of G will be greater when K is closed than when open, but if R be given a lower resistance than that of B, the closing of K will lessen the D of G.

In the present example, let a Thomson's reflecting gal-

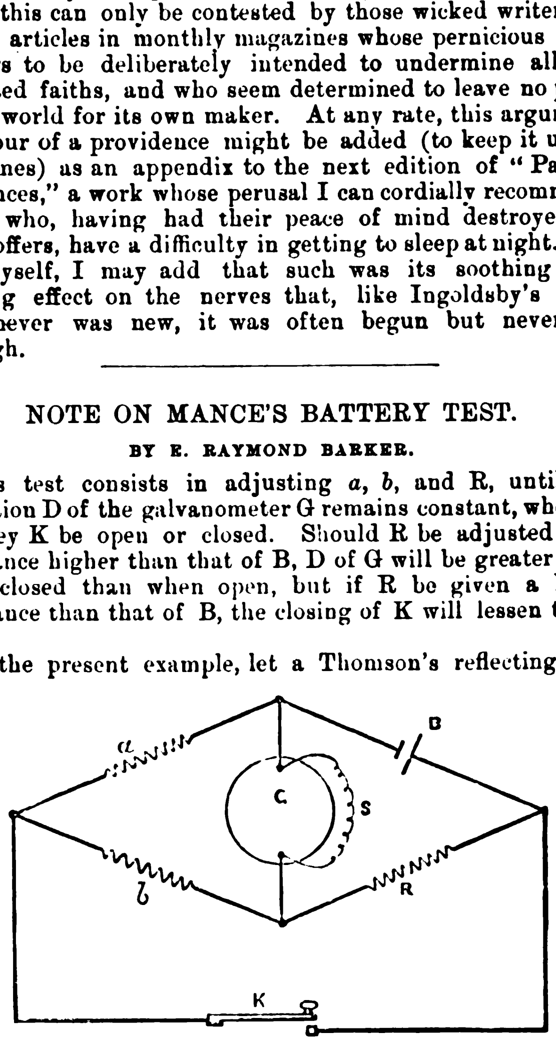

FIG. 1.

vanometer, G, be shunted with a short piece of "leading" wire, S, so that the resistance of G becomes practically *nil*, its sensitiveness being, however, sufficient to give an appreciable deflection. The theoretical arrangement of the test, as shown in Fig. 1, may be more clearly illustrated, as in Fig. 2.

Here we see B in circuit with R and the shunted galvanometer, the last-mentioned being still further shunted by the resistance $b + a$. With K *open*, however, the shunting action of $b + a$ upon G may be neglected, as G is already rendered of resistance *nil* by the short wire shunt S.

Then, with K *open*, the condition of things may be represented as in Fig. 3, but with K *closed*, the arrangement of the apparatus becomes as shown in Fig. 4.

Let us now inquire into the reason why, when equilibrium

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is produced, D of G remains constant, whether K be open or closed.

Let us suppose that equilibrium has been produced, and, for simplicity's sake, let us give the value of 10 ohms to each of the four resistances—a, b, B, and R.

Let R′ represent the total resistance in circuit when K is open, as in Fig. 3.

Let R″ be total resistance in circuit when K is closed, as in Fig. 4.

Then

1. *With* K *open*:—$R' = B + R = 10 + 10 = 20$ ohms.

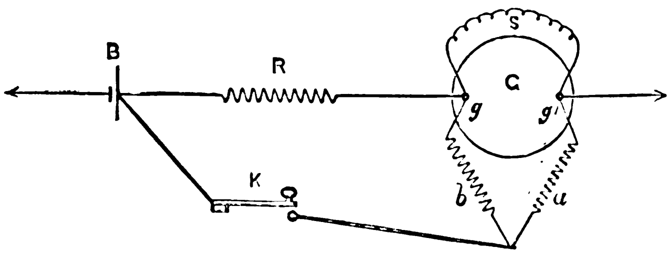

Fig. 2.

Under these conditions the whole of the battery current, say $\frac{3}{3}$ or three-thirds, traverses G, causing a D of, say, 80 divs.

2. *With* K *closed*:

$$R'' = B + \frac{\frac{Rb}{R+b} \times a}{\frac{Rb}{R+b} + a} = 10 + \frac{\frac{10 \times 10}{10 + 10} \times 10}{\frac{10 \times 10}{10 + 10} + 10}$$

$$= 10 + \frac{50}{15} = 13 \cdot 3 \text{ ohms.}$$

Here $R'' = 13 \cdot 3$ ohms, which is $\frac{2}{3}$ or *two-thirds* of 20 ohms, the value for R′.

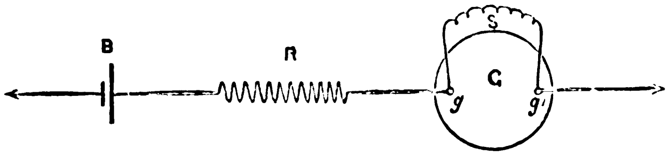

Fig. 3.

The total resistance in circuit being now *lessened* by *one third*, the conductivity of the circuit is therefore *increased* by *one third*, and were all the resistances a, b, and R to abut at one terminal g of G, the increased deflection due to a consequent increase in current would rise to about 80 + 40 = 120 divs. As, however, R and b only are connected to g, whilst a is carried on to terminal g', it is clear that the only current which will affect G will be that flowing through R and b, that is to say, through the joint resistance which we have seen $= \frac{10 \times 10}{10 + 10} = 5$ ohms.

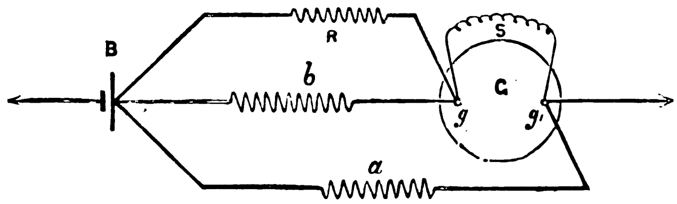

Fig. 4.

Now, this joint resistance in multiple arc of R and b is shunted by a of 10 ohms, the current in which latter in no way affects G, which is affected by that proportion only of current which traverses R and b.

Then, the system $\frac{Rb}{R+b}$ being of 5 ohms resistance, whilst the resistance of a is 10 ohms, it is clear that $\frac{2}{3}$ or *two-thirds* of the total current will traverse R and b, whilst $\frac{1}{3}$ will pass through a. Therefore, G is affected by only *two-thirds* of the passing current.

Thus it will be seen that the closing of the key K, besides *reducing* the total *resistance* from 20 to 13·3 ohms, that is to say, reducing R′ by *one-third*, and thereby *increasing* the total *current* by *one-third*, has also caused *one-third* of the increased current to be diverted from G. Therefore, in this instance, the increase brought about in the current by the closing of K in no way affects the D of G, for at the same time that the current becomes *increased* by *one-third*, *one-third* of the increased current is diverted from G, one operation exactly counterbalancing the other, so that the D of 80 divisions remains *constant whether* K *be open or closed*.

Having now ascertained the reason for the constancy of D of G when an equilibrium exists, that is to say when $a : b :: B : R$, let us now make an inquiry into the *rationale* of the fact that if R be of a higher resistance than B, D of G will be higher when K is open than when closed.

In the present example, let a, b, and B be each of a resistance of 10 ohms, whilst to R is given a resistance of 100 ohms. Under these conditions, we find that the closing of K considerably increases the D of G, thus showing that equilibrium has not been established, R being much higher in resistance than B.

Now, in the present instance, we have:—

1. *With* K *open*:

$$R' = B + R = 10 + 100 = 110 \text{ ohms.}$$

Under these conditions, let D of G be, say, 80 divisions.

2. *With* K *closed*:

$$R'' = B + \frac{\frac{Rb}{R+b} \times a}{\frac{Rb}{R+b} + a} = 10 + \frac{\frac{100 \times 10}{100 + 10} \times 10}{\frac{100 \times 10}{100 + 10} + 10}$$

$$= 10 + \frac{9 \cdot 09 \times 10}{9 \cdot 09 + 10} = 10 + 4 \cdot 76 = 14 \cdot 76 \text{ ohms.}$$

These figures show that the closing of K has increased the conductivity of the circuit $\frac{110}{14 \cdot 76}$ = nearly 7·452 times. This change would produce an increased deflection of $7 \cdot 452 \times 80 = 596 \cdot 16$ divisions, were the whole of the increased current allowed to influence G. However, the only current which affects G is that flowing through the system $\frac{Rb}{R+b}$ of 9·09 ohms.

Now, the conductivity of R shunted by b alone is seen to be increased $\frac{110}{19 \cdot 09} = 5 \cdot 7623$ times (for $B + \frac{Rb}{R+b} = 10 + 9 \cdot 09 = 19 \cdot 09$) so that the corresponding increase of current would produce an increased D of $80 \times 5 \cdot 7623$ = nearly 461 *divs.*, were it not that a of 10 ohms diverts nearly half the battery current from traversing G. If we suppose the current to consist of $a + \frac{Rb}{R+b} = 10 + 9 \cdot 09 = 19 \cdot 09$ parts, 10 parts may be said to traverse $\frac{Rb}{R+b}$, whilst 9·09 parts pass through a.

Now, it has been seen that 596·16 would have been the value for D of G had the whole of the increased current, after the closing of K, been allowed to traverse G. If this value be now divided by $\frac{19 \cdot 09}{9 \cdot 09}$, we obtain the value in divisions of scale for the actual D of G with K closed.

$$\frac{19 \cdot 09}{9 \cdot 09} = 2 \cdot 1001 \qquad \frac{596 \cdot 16}{2 \cdot 1001} = 283 \cdot 87 \text{ divisions.}$$

So, whilst with K open, we obtain a D of G of 80 divisions, with K closed D becomes increased to about 284 divs. This shows that, if R be greater than B, the galvanometer deflection will be larger when K is closed than when open. In like manner it might be shown that, were R adjusted to a lower resistance than B, the galvanometer deflection would be smaller when K was closed than when open.

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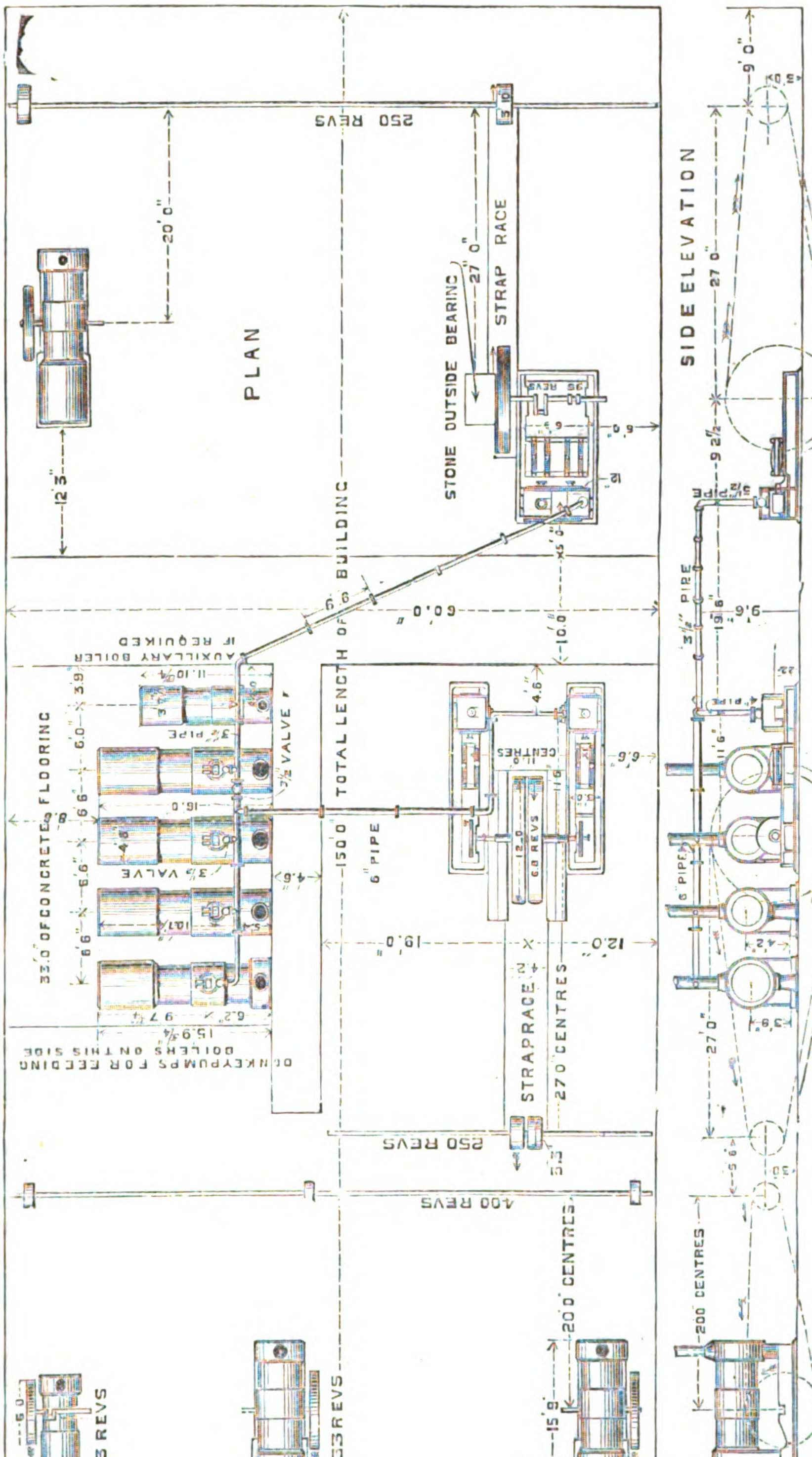
THE ELECTRIC LIGHTING INSTALLATION AT THE FISHERIES EXHIBITION.

In the history of electric lighting, the Great International Fisheries Exhibition of 1883 will be remarkable as having been lighted by the largest installation of its date. Larger displays of the electric light, as at the Crystal Palace Exhibition of 1882, have preceded it, but these consisted of a number of separate and distinct installations. For lighting the Fisheries Exhibition, however, a single installation has been arranged, and in one engine and machine room the whole of the electricity required throughout the exhibition buildings is generated and distributed by the several arc and incandescent lamp systems which belong to those who have



lent the dynamo-electric machines and other plant for the purpose.

In giving an account of a large installation like this, where about 1,100 or 1,200 indicated horse-power is employed, it is necessary to describe the different portions of

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the plant separately, and in classifying these we shall take them in the following order: Engines and boilers, and shafting, &c., dynamo-electric machines, lamps, conductors &c.

Arrangement of Engines.

We give herewith a plan of the engine and machine room, from which it will be seen that six engines are employed, namely, two horizontal fixed engines, three semi-portable engines, and one portable engine. The four last-mentioned are complete with boiler, and the two fixed engines are supplied with steam by five boilers of the locomotive type. The whole of these engines and boilers have been provided and lent to the Commissioners by Messrs. Davey, Paxman, and Co., of Colchester, the well-known makers of engines for this and similar purposes. The engines may be thus enumerated. One pair of horizontal stationary engines working on one crankshaft with two fly-wheels, as shown in the centre of the plan, and of from 350 to 400 indicated horse-power. One compound horizontal engine of 250 indicated horse-power. Three semi-portable engines, each capable of indicating 100 horse-power, and one portable engine capable of indicating about 80 horse-power, or a total of 1,030 indicated horse-power when the engines are running at the speed and with the normal pressure intended by Messrs. Paxman and Co. Considerably more power than this will, however, probably be developed by employing rather higher pressures and speeds. On the eastern part of the engine and machine room are placed the compound fixed engine and one of the semi-portable engines, both working one line of shafting 5in. in diameter. This runs at 250 revolutions per minute, a rather high speed for such shafting, but one which reduces the necessary size of the pulleys upon it by which the dynamo machines are driven.

(TO BE CONTINUED.)

ON THE HEATS OF COMBINATION OF THE METALS WITH THE HALOGENS.*

BY A. P. LAURIE, B.SC. AND C.I. BURTON.

At the last meeting of the society a paper was communication by us, describing a new method for determining the heats of combination of the metals with the halogens. The following paper is an account of our preliminary experiments mentioned in the former paper. As these experiments were all made with modifications of the "iodine cell," or of the "cuprous iodide cell," we shall begin with a brief description of these two cells.

The iodine cell consists of a carbon rod and a zinc rod immersed in a solution of iodine in iodide of zinc. The cuprous iodide cell consists of a zinc plate and a copper plate immersed in a solution of iodide of zinc, the copper plate being covered with a paste of cuprous iodide, and then wrapped in parchment paper.

The E.M.F's of the cells were measured on a Thomson quadrant electrometer, the deflection corresponding to 1 volt, being found by measuring the deflection given by a Daniell cell. The Daniell cell was assumed to have an E.M.F. of 1·12 volt. This is not a strictly accurate assumption, but was sufficient for these preliminary experiments. The deflection given by the Daniell cell was measured at the beginning and end of each series of experiments. The zero of the instrument was usually noted after each deflection.

The formula used has been already mentioned. It is

$$\theta = \frac{E}{Je}, \text{ or } \theta = \frac{E}{4{\cdot}2 \times 10^7 \times e} \text{ (in C.-G.-S. units):}$$

e is equal to ·003411 grm. for zinc.

On connecting an iodine cell as above described with the electrometer, zinc as the active metal gave a deflection of sixty divisions on the electrometer scale. (The deflection given by a Daniell cell was 52 divisions.)

* From the *Proceedings* of the Royal Society of Edinburgh.

Copper, as the positive metal, gave no deflection. This was due to the coating of iodide formed on it by the iodine solution. It seems under these circumstances to be in a similar state to negative iron.

We then constructed an iodine cell in the following manner:—

In the centre of a glass vessel containing a solution of an iodide is placed a porous pot, containing the iodine solution and the carbon rod. Closely surrounding the porous pot is a cylinder of perforated zinc with which the iodine combines as fast as it diffuses through the porous pot. In this way the iodide solution in the outer vessel is quite free from iodine.

Experiments with this cell give as an average of five experiments—

Deflection with zinc, 63, in terms of the electrometer scale. As already mentioned, the E.M.F. of zinc in the ordinary iodine cell is about 60.

The difference 3 is due to an E.M.F. set up between the iodine solution and the iodide of zinc solution.

The deflection with copper is 33.

Some experiments were then made with a cuprous iodide cell constructed in the manner already described. The following table contains the results:—

Name of Metal.	E.M.F. in Iodine Cell.	Calculated E.M.F. in Cuprous iodide Cell.	Found E.M.F. in Cuprous Iodide Cell.
Zinc	60·5	30	32
Copper	30·5	0	0
Silver	29	− 1·5	0
Lead	39	8·5	10
Tin	29	...	...
Iron	31	·5	0

The second column of figures is found on the assumption that the E.M.F. of a metal in the cuprous iodide cell is its E.M.F. in the iodine cell, *minus* the E.M.F. of copper in the iodine cell.

Three has been subtracted from the numbers in the first column. The reason for doing this has been already explained. Taking 61·5 as the E.M.F. of zinc, which is the mean value, its heat of combination with iodine as calculated from the above formula is 924.

The number given by Naumann for the heat of combination of zinc with iodine in presence of water is 929.

Nearly all our other numbers agree approximately with those given in Naumann's "Thermochemie."

The numbers, taken from Naumann's table, are the heats of combination of one gramme of the metals in presence of water. It will be seen that the value given for iron by Naumann does not show any agreement with our value. This is also the case with the chlorine and bromine compounds of iron.

Reaction.	E.M.F. of Metal.	Heats of Combination, calculated from E.M.F.	Heats of Combination, from Naumann's Table.*
$Zn + I_2 = Zn\,I_2$	1·324 volts.	924 heat units.	929 heat units.
$Cu_2 + I_2 = Cu_2I_2$	·657 „	235 „	256 „
$Ag_2 + I_2 = Ag_2I_2$	·624 „	131 „	127 „
$Pb + I_2 = PbI_2$	·861 „	189 „	191 „
$Fe + I_2 = FeI_2$.	·667 „	523 „	851 „

In order to test the effect of temperature on the E.M.F. of the cell, the E.M.F. of zinc in an iodine cell was measured when the cell was at 11° C., and when it was at 27° C. The E.M.F. in both cases was the same.

* At the time this paper was read we had not seen Naumann's "Thermochemie" (published 1882). The above values have therefore been inserted since then. They are much nearer our own than the values given in the older books.

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The deflection given by silver wire and silver electrolytically deposited from pure nitrate of silver is the same.

Iron wire with a blue tarnish on it gives a considerably less deflection than clean iron.

The E.M.F. given by alloys seemed to us to be of considerable interest. We supposed that they would give the E.M.F. of their most positive constituent. This, however, is not always the case. Solder gives a deflection of 40 (lead = 40, tin = 32), but brass gives the same deflection as copper, namely, 33. A confirmation of this is the fact that brass and copper give no E.M.F. in dilute sulphuric acid.

After having made these experiments with the iodine cell, we made a chlorine cell by filling the porous pot with a freshly prepared solution of chlorine. The results with the chlorine cell do not agree well with the results found in the cuprous chloride cell, and the heats of combination calculated from the electromotive forces in the chlorine cell must be regarded as very rough approximations. Two values are worth mentioning. The heat of combination of 1 gramme of zinc with chlorine, calculated from its E.M.F. in the chlorine cell, is 1,578 heat units. The number given by Naumann is 1,736 heat units. Naumann's value, with a correction which has not been made for the heat of solution of chlorine, is about 1,660 heat units. The heat of formation of $Cu_2 Cl_2$ from the E.M.F. of copper in the chlorine cell is 493 heat units. The number given by Naumann is 517 heat units.

We have made a few experiments with a bromine cell, but as we have not made any with a copper bromide cell, it is unnecessary to give them at present.

One experiment is mentioned in this paper, testing the influence of temperature on the E.M.F. of the iodine cell. This has become a matter of some importance. In a paper by Helmholtz, to which we referred in our last communication, it is shown that the difference of E.M.F. at different temperatures is possibly the measure of the work done in the cell which does not appear in the electric current.

In conclusion, the results derived from the iodine and cuprous iodide cell seem fairly satisfactory.

Probably the best way to test the accuracy of the method would be to run down an iodine cell in a calorimeter, and compare the heat evolved by the solution of a given weight of zinc with the value calculated from the electromotive force of the cell. We propose to make some experiments in this direction.

TABLE KEY, SWITCH, AND ANNUNCIATOR FOR TELEPHONIC PURPOSES.

DESIGNED BY MAGNUS VOLK.

The table key as shown in Fig. 1 has a substantial brass

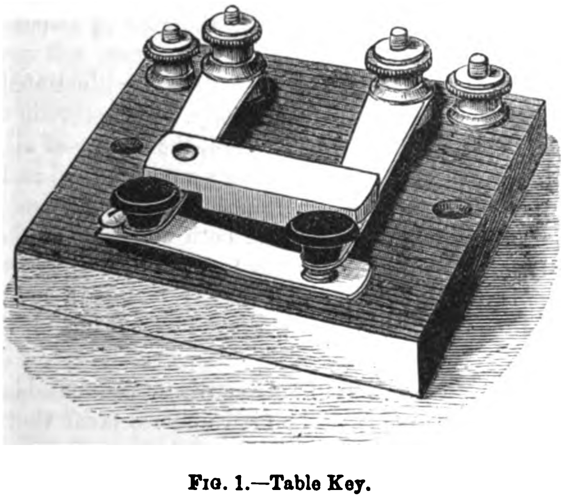

FIG. 1.—Table Key.

bridge over the keys, instead of the usual bent metal brackets, and the bottom left-hand contact (under the speaking key) is made with a spring that rises and falls a short distance so that the minute tremors of the hand may not make and break contact. The left-hand key is prevented from touching the bridge by an ebonite stud. The board is 4in. by $4\frac{1}{2}$in.

The switch (Fig. 2), which acts as a commutator, has long springs made of hard metal, and all the contacts are sliding, and very firmly made. The bottom left-hand spring is in metallic contact with the pins shown at B, but insulated from the

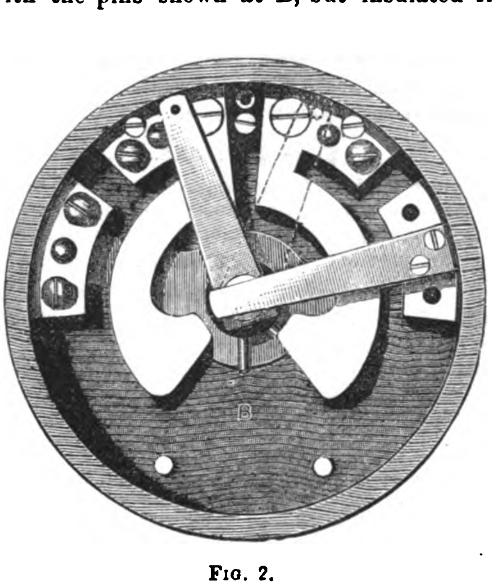

FIG. 2.

movable arm and top right-hand spring, which are in metallic contact. The blocks of the right-hand top spring should show holding down screws, the same as the other blocks. The diameter of the switch is $3\frac{3}{4}$in.

The annunciator (Fig. 3) is so constructed that there are no loose coil ends to the coils; the bolts at the back are insulated from the frame, but connected to the pins at the side, to which the coil ends are soldered, so that the whole can be

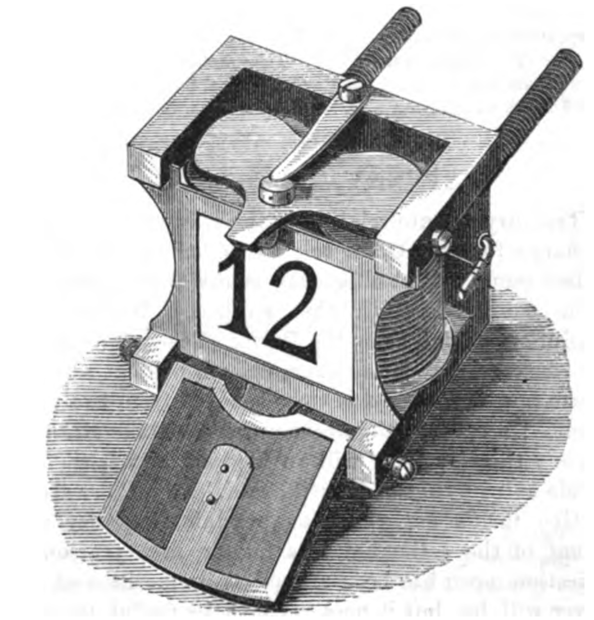

FIG. 3.

attached to a flat board and held by two nuts, the line and earth connections coming between the first and second nuts on the bolt. The card, on which is printed the number, slides into a German silver frame. These annunciators are also made polarised, which very much increases their sensitiveness. When made as illustrated, the shutter will be released through a resistance of 150 ohms, using four cells. The size is $1\frac{1}{2}$in. square by $1\frac{1}{4}$in. deep.

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THE ELECTRICIAN.

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All letters intended for insertion in THE ELECTRICIAN, *or containing questions, must be accompanied by the name and address of the writer, not necessarily for publication, but as a proof of good faith. No notice whatever will be taken of anonymous communications.*

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SIXPENNY TELEGRAMS.

The Treasury minute relating to the reduction of the minimum charge for Post Office telegrams, which we published in our last issue, will at all events narrow some of the issues raised in connection with this subject. We now know the resolution arrived at by the House of Commons in March last is to be carried out, and the minimum price at which telegrams are now despatched is to be reduced from twelvepence to sixpence; secondly, the decision will not take effect until next year; thirdly, there will in any case be a large outlay to provide extra means of transit; and, lastly, there are three alternative tariffs suggested as possible, together with a statement of the estimated loss for the first year on each. The question never has been argued on its merits, and probably never will be, but it may perhaps be useful to consider the relative merits of the several tariffs from which a choice has now to be made. The expenditure of capital calls for no remark. The estimate is not excessive, and will probably prove insufficient, but that is the Treasury's affair now that the country has decided on a measure that cannot be carried out except at great and uncertain cost. Similarly, the estimated loss arising from the adoption of a cheap tariff admits of no discussion; the only remark deserving of notice on this point being that it is a pity the people who are able to predict with such exactitude the loss on the first year have not been asked to favour us with the probable loss for all years to follow. It has long been a subject of complaint that the telegraphs did not pay their way. That they will ever do so in the future is now rendered well nigh impossible; but we are to have sixpenny telegrams instead, and it is therefore a matter of little moment whether the loss will be a third of a million, a quarter of a million, or a million. Having decided to buy our whistle we must pay for it; and this being so, the Chancellor of the Exchequer's deprecatory remarks on the "too heavy" charge involved by the adoption of "Scale 3" go for absolutely nothing.

The question, then, is which of the three scales would it be best to adopt? This, at least, would be the question if we were arguing with people who could exercise their judgment independently. But we know that crotcheteers and hobby-riders will be the final arbiters in legislation of this sort, and we must reckon with them. It is, however, a matter of congratulation that the various fancy tariffs of one kind or other put forward in *The Times* newspaper have no place in the Treasury minute, and we need not discuss them here. From the scales alone officially put forward a selection will no doubt be made. They all alike stipulate that the charge shall not be less than sixpence, however few the words contained in the despatch, and in respect to one of them provision is made that the present charge for twenty words shall not be exceeded. Sixpence for the first five words, and twopence additional for each subsequent five words, the addresses to be free, which is Scale 3, means exactly 1s. for twenty words, as at present, but leaves it open to the sender to reduce the charge by 6d., which he cannot do at present. Scale 2 includes in this charge the name and address of the sender, and would, if adopted, therefore, require a fresh Bill to amend the Telegraph Act, for the cost of twenty words of text would then exceed the present limit. The other scale, placed first in the minute as being the simplest and best understood, makes a uniform charge of a halfpenny for every word, whether of text or addresses.

The choice will probably rest between the last-named scale and Scale 3. Most of the objections that may be urged against either or both these scales apply to Scale 2. The charge for sender's address would yield very little revenue, as senders would reduce it to a mere signature, the department gaining only indirectly by the burden being lightened, whilst a portion of the public—an inconsiderable portion it is true—would feel the charge vexatious and illogical. We may here observe that one important condition in Scale 2 is left in uncertainty. If the sender's address comes first, as at present, it will be chargeable at the rate of sixpence for five words; if it comes last the twopenny rate will cover it. The absurdity of Scale 2 cannot be better illustrated than by this utterly indefensible anomaly. To a certain extent Scale 3 is open to the same objection, the charge of sixpence for the first five words of text being a very artificial and arbitrary way of obtaining the initial charge. But as seven words would ordinarily suffice for both addresses in the vast majority of telegrams, it comes to the same thing whether sixpence is charged for the first line of text or a halfpenny per word for the first twelve words, addresses included, as in Scale 1.

We say seven words would ordinarily suffice for addresses; probably even fewer would be used under a tariff that taxed them. But in practice it does not half suffice, and the difference to the revenue between a tariff which taxes all words, and one in which the text alone is taxed is enormous, for the public, while using their best endeavour to cut the chargeable words down, will proportionately be indifferent

about the number of their non-chargeable words. People of Alderman Lawrence's way of thinking no doubt are serious in regarding the curtailment of addresses as a hardship, especially to the non-commercial and poorer classes. The curtailment of the text is, however, hardly less so; and the real question turns—or ought to turn—upon whether the proposal is equitable. His own way of putting it is not equitable. It is, indeed, already "recognised that much longer addresses are required by artisans and small traders than by merchants and bankers." What is not sufficiently recognised is the undeniable fact that the first-named classes require much shorter text; and it is perfectly evident that if they are to be unrestricted in the matter of addresses, as at present, the other classes must pay for them; that is to say, pay for a privilege they do not desire for themselves, and one which the other classes would be just as well without. This is not all; the unlimited free addresses means an extravagant lengthening of every despatch, and consequent unnecessary time occupied in transmission. If the present speed of transit is to be maintained under a more popular tariff, short messages, very short messages, must be the rule. Every sound argument founded on knowledge and experience tells in favour of Scale 1; popular sentiment, however, is at present opposed to it, and probably Scale 3 is the one most in favour with people who value popularity more than wise counsel. Possibly, but only possibly, between now and next Session the public may discover that five words for sixpence does not quite realise what they expected of a "sixpenny telegram," and they may then condescend to examine an alternative proposal which, if they choose, would give them more for their money.

CORRESPONDENCE.

FIXING MAGNETIC LINES IN FILINGS.

TO THE EDITOR OF THE ELECTRICIAN.

Sir: I find ordinary "sticking plaster" answers admirably for this purpose, and is better in some respects than either the paraffined paper or gummed paper arrangements.

The plaster is first pasted on a card, to be placed on the magnet when a good arrangement of filings has been obtained. A heated iron held near softens the preparation on the plaster, and causes the filings to adhere firmly on cooling.—Yours, &c., J. Brown.

Belfast.

ACCUMULATORS—A CURE FOR SPLUTTERING.

TO THE EDITOR OF THE ELECTRICIAN.

Sir: Many of your readers who have experimented with accumulators have no doubt been troubled with the spluttering from the liquid while in action. To obviate this, I should advise them to try the well-known remedy of "oil on troubled waters," viz., by covering the liquid with paraffin or petroleum oil, both as pure as possible.—Yours, &c.,

June 4, 1883. F. B.

MEDICAL ELECTRICITY.

TO THE EDITOR OF THE ELECTRICIAN.

Sir: I am much obliged to "Sigma" for his kindness in replying to my inquiry, "How to make a make a magnetic belt." I am satisfied he has given me the very best method known, notwithstanding the irony with which his letter abounds.

I am also much indebted to Mr. Bennett for his very kind offer to give information on the application of electricity for the cure of disease, which I willingly accept, more especially as "Sigma" says the subject is worth a place in your columns. With many thanks for the insertion of my inquiry in your pages.—Yours, &c., Neuralgia.

TO THE EDITOR OF THE ELECTRICIAN.

Sir: I shall look with interest for the article in *Health* by Mr. Lant Carpenter; meanwhile I now endeavour to give in a practical way (not pretending to be scientific) the modes in which an interrupted current may exercise its medical virtues.

1. Its action as a stimulant to motor action, causing rapid contractions and relations of muscular tissue, whereby the circulation of the blood is promoted just as it is by friction or healthy exercise. Promoted circulation burns and carries away waste or diseased matter, which, if left, causes pain or even serious maladies.

We all know the history of the blacksmith's arm, and draw the inference that exercise strengthens. So it is when a weak or paralysed muscle or set of muscles is or are galvanised. Cases which have come before my notice are:—The muscles of the stomach and rectum, in cases of dyspepsia and of constipation, were made to perform their function permanently much more vigorously than before. In irregular secretion of bile, the liver similarly strengthened. In a case of deafness, the action of the eustachian tube was to a great extent restored. Where the facial muscles were weak on one side, and caused a deformity of expression, galvanising to a great extent restored the disfigurement.

Then as to cases in which by the *temporary* action of this stimulant a natural action is performed, which would not be without it, either directly or by promoted circulation. The direct action probably takes place in dyspepsia and in bronchitis. In the latter the bronchial tubes being cleared of the obstructive mucus, the patient breathes more freely, and has a better chance of recovery. The indirect action probably takes place in rheumatism and fevers.

Before leaving the subject of motor action I may mention that the muscles of the leg, arm, hand, and others (amongst them those of the urethra) may be made to respond more freely to the will.

2. A sensory action. Often do most of us, engineers and business men, return to our homes with an over-worked irritable feeling, seeming to forbid a good night's rest. In such a state I have gone to my coil, galvanised, and fallen asleep under its action.

There are times, particularly with the weaker and naturally suffering sex, when sleep gained is of no small importance.

The power to *weep* may be as important.

All her maidens watchful said
"She must weep or she must die,"

runs Tennyson's poem. The electric currents may bring about this necessary nervous crisis, as did the sight of the child.

3. Another probable cause of benefit, but which I do not insist on, is this: sometimes, between the electrodes and the skin, and I think not improbably in the tissues themselves, minute arcs are formed, and these convert a portion of the oxygen in their vicinity into ozone; this burns waste matters. Other chemical actions, too, follow an arc discharge.

4. Overcoming the resistance of skin and tissue, the currents produce *heat*. An almost infinitesimal gain repeated many times a minute may become a definite benefit in an hour. Heat is a powerful agent in removing congestive diseases, and often a gain on the principles of economy of energy.

Now, I cannot conceive the whole of these effects as a mere result of "muscular friction," as Mr. Sprague thinks them.

Further, were it so, the ratio of medical efficiency of two interrupted currents would be approximately according to their respective electromotive forces. But in practice we find the coils producing the best results are those in which a considerable quantity of wire, *not very fine*, and a low working E.M.F. are the essential features. In other words, shocks or great "muscular friction" are to be avoided in most instances.

The natural and logical conclusion is that, whatever the

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cause of nervous action may be (Professor Huxley owns he does not know it, and, therefore, we cannot accurately explain its excitation), yet, as experiments go to show, the laws of the conservation of energy are here as truly, as in the thunderstorm and everywhere, the keys to unlock mysticism. To make coil construction easy, then, let us remember that in all sound electrical work our guiding principle is $C^2R = W$. —Yours, &c., A. W. BENNETT.

Black Boy Yard, Long Row, Nottingham,
July 7, 1883.

HONOUR TO WHOM HONOUR IS DUE!

EDWARD DAVY AND THE ELECTRIC TELEGRAPH, 1836 TO 1839.

BY J. J. FAHIE, MEMB. SOC. TEL.-ENGS. AND ELECS.

(CONTINUED FROM PAGE 186).

Returning to our examination of the Davy MSS., we find a memorandum of another modification of the screen arrangement, which would require only two line wires (and one return wire), and yet would yield twelve elementary signals. This contrivance, which is fully explained, need not, however, detain us further than to indicate the highly ingenious plan adopted for producing some of the necessary changes of the screens. It consisted in the employment, at certain times, of batteries of *different strengths* (they being of necessity of opposite signs), so as to determine, at those times, a current of positive, or negative, sign in the return wire, and thereby actuate screens which, if the currents had been of *equal strength,* would, of course, be inoperative. This neat and effective arrangement was utilised in another of Davy's instruments, of which we must now say a few words.

fessor Faraday, who gave it as his opinion that the two inventions were distinct, the Solicitor-General quashed the opposition, and allowed the application to pass.

The *modus operandi* may be briefly described as follows*:—C, C, C, in Fig. 4, is the key-board, having three pairs of keys, so connected with three separate batteries as, on depressing any one of them (the keys), to cause a current of positive, or negative, sign, as the case may be, to flow through the line wire in connection with it, and close one, or other, of the relays at the distant end. This operation brings into play the local battery, V, whose current, setting out, from, say, the copper plate, passes through the electro-magnet, *n*, *n*, drum and chemically-prepared cloth, *a*, one or other of the platinum-tipped discs, *y*, *z*, one or other of the relay tongues according to the key depressed, and thence back to the zinc plate. The result is (1) that a mark is made on the cloth where the current passes, and (2) that the armature of the electro-magnet, on being attracted, draws an escapement from the cog-wheel, *e*, and so allows the platinum-covered drum, *a*, to revolve and carry forward the cloth through a space equal to the cross-bars shown upon it.

By sending positive and negative currents into one or more wires, variously combined, Davy was able to indicate twelve elementary signals, viz., the numerals 1 to 0, and A and Z, which, with the aid of a code-book, or dictionary, sufficed to express every word in the language, as well as a number of whole phrases, or conventional signs.

On this point Davy says, at page 117 of his specification, "three wires, A, B, and C, with two batteries, Nos. 1, and 2, will produce eight different signals, signs, or indications, and by using a third battery, No. 3, and having needles [*i.e.*, relays] applied to the common communicating wire, C, twelve different signals, indications, or signs may be transmitted, the object in using a third battery, in such case, being to give

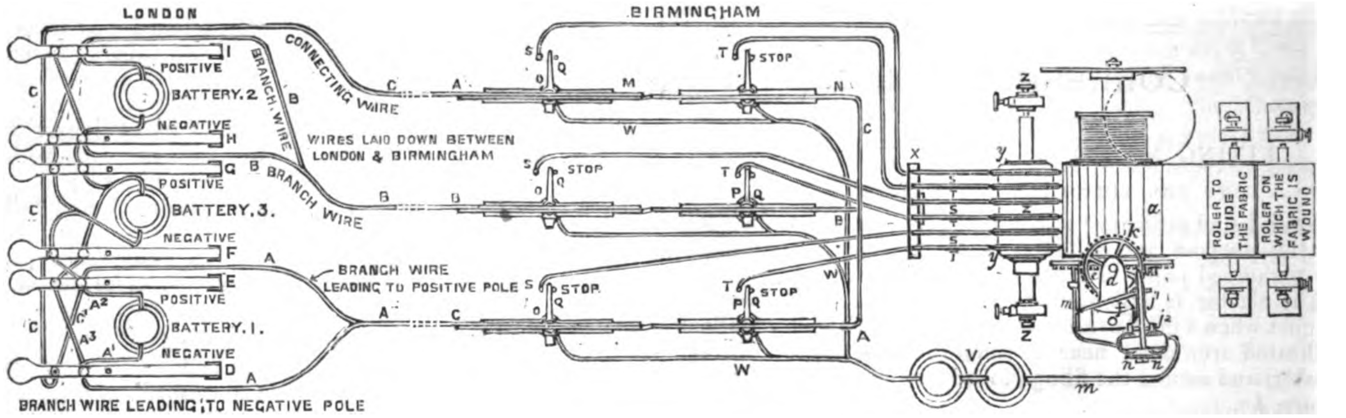

FIG. 4.

The recording telegraph is a very beautiful piece of mechanism—the first of a long line of chemical telegraphs—and we cannot help thinking that, had it had a fair start in 1838, and been fined down by practice, as it could have been, and as Cooke and Wheatstone's first inventions were, it would have given to English telegraphy an entirely different character from that impressed upon it by the rival plans, and chemical telegraphs would now be the rule instead of the exception.

Like all his other inventions in telegraphy, Davy perfected this apparatus before December, 1837, or, as he says in his "Statement," before the enrolment of Cooke and Wheatstone's first specification, of the nature of which he was, at the time, in perfect ignorance, "except in so far as it could be gathered from paragraphs in the newspapers, which conveyed really no information."

He wished to take out a patent at once for this instrument, but, owing to legal formalities, and the opposition of Cooke and Wheatstone, the specification was not sealed until July 4, 1838. The opposition appears to have been based on the plea that some parts of Davy's mechanism were infringements of their patent of June, 1837,* but, on a reference to Pro-

* Davy's MSS. contain some warm passages on this most unfair charge.

greater quantity of electricity to certain currents; thus, supposing a positive electric current to be passing through the wire, A, and a negative electric current to be passing through the wire, B, there would be two electric currents passing to the wire, C, in opposite directions, consequently the needles [relays] on the wire, C, would not be acted on in such manner as to obtain a certain and definite indication, or signal, unless the positive, or negative, current passing to the wire, C, be made more powerful than the other, and this may readily be effected by the keys, F, G, which can bring the wires, A, C, B, C, in connection, or metallic communication with the battery, No. 3, in addition to their own battery, and thus give more power to one of the currents passing through the wire C."

Following the original drafts of this apparatus, which are preserved amongst the Davy MSS., we find a description of another telegraphic project, which, as our readers will observe, is based on the same electrical principles as the diplex and quadruplex systems of the present day. It is a mode of obtaining one, two, or more signals through a single pair of wires by means of currents of one, two, or more degrees of

* Those who desire a fuller account will find it in the specification which can be obtained at the Patent Office for a small sum. It contains all the accessories of a complete telegraphic system, many of which have already been described in these pages.

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strength, acting on needles so weighted as only to respond to the currents destined to move them.

For the signal-indicating part of this plan, Davy proposed to employ a new form of galvanometer, which he called an "electro-magnetometer," and which he had designed, in the first place, "for measuring with greater precision than heretofore the exact quantity of electricity passing in any given circuit." This instrument is figured and described in his patent of July 4, 1838, pages 16-17.

Foreseeing that to operate a telegraph of this kind it would be necessary to regulate, and keep regulated, the currents with great accuracy, Davy devised, for this purpose, a very beautiful "self-regulating galvanic battery." "The principle of the contrivance," to quote his own words, "is that as soon as the magnetic energy of its electric current rises above, or falls below, a certain required standard one of the metals of the galvanic pair is, by the agency of this magnetic energy, either raised out of, or further depressed into, the acid, or exciting liquid, in the cell; so as to become, thereby, less, or more, exposed to the action of the liquid; the extent of its exposure regulating the quantity of electricity generated.

"To effect this intention, there are two coils in the conducting wire proceeding from the battery:—in which are two of my electro-magnetometer needles. Of these needles the dipping end of one is a certain degree heavier than that of the other; and the intention is that the electric current should remain within the limits of the two; so as just to act upon the lighter: but not on the heavier.

"Now, if the current be too powerful the heavier needle, by dipping, will cause a communication between a fresh, or distinct, source of electricity and the two wires *a*, and *b*, attached to platina plates in dilute sulphuric acid contained in the air-tight tube, *c*. Then by the decomposition of the water, gases will be evolved, and depress the liquid at *c*, and also the mercury below it, *d*, so as to elevate the piston, *e*, and its rod, *f*, whereby the lever, *g*, is also elevated, and lifts the metallic plate, *h*, belonging to the galvanic battery, so as to diminish the energy of the said battery to the required degree.

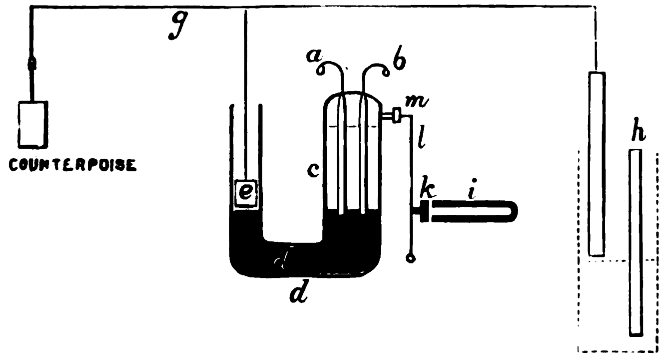

Fig. 5. (Drawn from original manuscript.)

"If, on the other hand, the electric current be too feeble, then the lighter needle will fall and open a communication with the distinct source of electricity through the coil of wire which surrounds the electro-magnet, *i*, whereby it is rendered temporarily magnetic and attracts the piece of iron *k*, which, thro' the lever, *l*, removes a caoutchouc (or other suitable) stopper from the minute aperture at, *m*, so as to allow the gas in the tube, *c*, to escape until the metallic plate, *h*, has again sunk sufficiently into the liquid in the battery cell to generate the required, or standard, quantity of electricity, such standard being allowed to vary between these minute differences only.

"Having thus obtained the element of a uniform battery, the quantity of electricity to be transmitted thro' the circuit may be regulated either by the number of such batteries uniting their currents, or else the current from one battery may be divided, and the mode of so dividing it is the remaining consideration.

"The electric current may be made to travel thro' pieces of platina, or other wire, of different diameters, and of given lengths, so that the thicker the wire, the greater will be the quantity of electricity to pass:—the exact dimensions of these to be regulated by actual experiment,* and, in order to obviate their ignition and combustion, they may be arranged under water, or, should water be objectionable, under some non-conducting, and non-electro-decomposable liquid, such as sulphuret of carbon, or naphtha, or whatever other may be found advisable."

From amongst Davy's miscellaneous memoranda we select two or three, with which we must close this portion of our work. In the first our readers will, we doubt not, be amazed, as we were ourselves, to find how near the writer was to discovering the telephone in 1837-8.

"19. The plan suggested (100) *where the signals are shown by reflection.*

"20. The plan proposed (101) of propagating communications *by the conjoint agency of sound and electricity—the original sound producing vibrations, which cause sympathetic vibrations in a unison sounding apparatus at a distance, this last vibration causing a renewing wire to dip† and magnetise soft iron so as to repeat the sound, and so on, in unlimited succession.*"

The sheet from which we copy these remarkable words is headed "Exclusive Claims," and seems to have served as an *aide memoire* to the drawing up of his patent specification. If our surmise be correct it would fix the date of the paper as not later than the beginning of February, 1838, for we shall see, later on, that he was, in that month, submitting his inventions to Mr. Carpmael, a well-known patent agent of that period. Unfortunately we can find no further mention of the "plan proposed," and can only surmise that Davy designed some kind of telephonic relay.

In the following memorandum the writer could only have in view a form of cell, which is now so well and so deservedly esteemed under the name of its recent inventor, M. Leclanché:—

"*A New Galvanic Battery,*

"A particular mode of using oxide of manganese as the electro-negative element of the battery, or in connection with the electro-negative plate.

"Certain other improvements in the battery, which will be described, if there be any opposition on this head,

"*An Improved Magneto-Electric Machine,*

"To be described if there be any opposition on this head."

The following extracts are from a paper headed—

Elemental Forces and Alarums.

There are two objects for which alarums may be required as essential appendages to the Electrical Telegraph.

1st. To give notice that communications are about to be sent, and call the attention of the person who is to receive them. For this purpose alarums of great loudness will not generally be required, unless the party be asleep, or not in the same room, and even in these cases a moderate loudness will suffice.

2nd. To give notice of accidents on a railway, or in other cases where the alarum may require to be heard by persons who may be at a distance at the time.

1st. With the first object an alarum is easily made. One of my horizontal dipping needles (surrounded by its coil), may have an upright rod, as a radius from its axis, with a little hammer on a spring, to strike a small bell by the deflection, or dip, of the needle. Thus two needles in the same wire may strike two distinct bells and produce a kind of chime; either one, or both, or variations of which, may be advantageously used according to the intention of the alarum.

* * * * *

2nd. Whenever an almost irresistable, or, at least, very great power is required, either to produce alarums, or for any other purpose, I claim the following mode of effecting

* Here we have the rheostat, or set of resistance coils, as used at the present day.

† *i.e.*, causing a relay to close a local circuit containing an electro-magnet. Davy always speaks of the relay as the "renewer," or the "renewing wire." By dip he means to dip into mercury, or, as we say nowadays, to close the circuit.

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the object, which is also applicable in other cases where temporary magnetisation may prove insufficient.

A piece of platina wire, *a*, connected with the opposite poles of the conducting wire, *b*, and *c*, is securely enclosed in an air-tight, and strong vessel, *d*, *d*, in contact, or proximity, with a quantity of sulphuret of carbon, or other suitable volatile liquid. Then the current of electricity from *b*, to *c*, will ignite, or heat, the platina wire *a*, so as to convert a portion of the volatile liquid into vapour, which will then

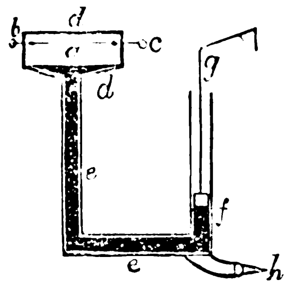

FIG. 6. (Drawn from original manuscript.)

expand with a degree of force, proportioned to the heat of the platina wire, and its continuance in a heated state. This will force the mercury, which is below the volatile liquid through the tube *e*, *e*, so as to elevate the piston at *f*, and *g*. The force thus obtained may be applied to any required purposes.

When the current of electricity ceases to pass, the sulphuret of carbon, or other volatile liquid, will re-condense, and the piston gradually resume its former position without the necessity for an attendant to liberate the vapour. Of course a safety valve may be attached, if necessary, either at *h* or at *d*, *c*, and the self-regulating battery would be useful in combination with this contrivance.

A continuous sound may be produced by applying either of the above-mentioned forces to open a valve so as to admit air, or gas, from a vessel containing such air, or gas, under compression through a whistle, horn, or other wind instrument. Air, or gas, under compression for this purpose may be provided by the action of dilute sulphuric acid on old iron, on the principle of the hydrogen instantaneous light apparatus, where, as soon as a certain quantity of gas is generated, the liquid is forced into another part of the vessel so as no longer to act on the metal; or air may be pumped in from time to time.'

As we have frequently in the course of these pages referred to Davy's "Statement," we think it advisable to reproduce this important document, as, while confirming our chronology, it will also serve as an excellent *resumé* of the writer's leading discoveries :—

Statement.

The idea of an electrical telegraph first occurred to me about the year 1836, at which time I was not aware but that it was perfectly original. In the commencement of 1837, having tried some experiments with a mile of copper wire in the Regent's Park, aided by my friend, Mr. Grave, I entered a *caveat*, in March, and, about the same time, I deposited with Mr. Aikin, Secretary of the Society of Arts, a sealed description of my invention, in its then state.

My earliest idea of applying the deflection of the needle for telegraphic purposes, was similar to that since claimed as a new invention by Alexander, with a common return wire. The next improvement was the obtaining the two actions upon each needle by the reverse currents. Then, the fixing two, instead of one needle, in each circuit, and subsequently, the system of permutation described, with the use of the colour needles, and the employment of more than one battery. It was at this stage (in March 1837) that I first heard of Professor Wheatstone being engaged in the same subject, which led me to enter the *caveat*. Shortly after this, the idea of the renewing needles [relay] occurred to me. This was after a conversation on the subject with Mr. Bush of the Great Western Railway.

In May 1837, Messrs. Cooke and Wheatstone applied for a patent, to which I entered opposition, having provided myself with a written description of my inventions, and prepared to attest it by the evidence of several confidential friends. This evidence will be partly direct, and partly corroborative. I have Dr. Grant, Mr. Thornthwaite, and Mr. Hebert, besides the workman who helped me to make the models, and the Solicitor-General, on some specific, but all-sufficient, points. The paper was carefully inspected by my friends, who were also present at the hearing on the opposition.

The Solicitor-General at the time gave an opinion that the two inventions were different, and allowed the patent to pass: although time has since shown that they contained some of the clearest identities.

My remedies for the injustice thus sustained are, that I may move a writ of *scire facias* to set aside and annul Messrs. Cooke and Co.'s patent, on the ground that the Crown was misled in granting it,—or else, or after failing that, to act upon the [my] invention so that they may bring an action for infringement, which I have ample grounds for defending, and the failure of which will *virtually* render their patent void.

Litigation of this kind, which will be highly injurious to one party, and but partially beneficial to the other, is what it is in every way desirable to avoid, if the matter can be otherwise adjusted.

From the time of this decision (May 1837) up to the time of the enrolment of their specification in December, I was in perfect ignorance of the nature of their invention, except in as far as it could be gathered from paragraphs in the newspapers, which conveyed really no information.

In the meantime I introduced into my plans first, the use of screens, then the means of determinining the signals to specific places exclusively, and finally, that which I believe is calculated to supersede all others, the recording telegraph by electro-chemical decomposition.*

As showing Davy's wonderful perception of the uses which the telegraph would subserve, as well in the internal economy of railways, as in the political economy of the nation, and of the world at large, we give below the concluding portion of a lecture, which bears evidence of having been written about the middle of 1838,† but which appears never to have been delivered :—

"The point which now remains for consideration is, of what use will this electrical telegraph be? What are its applications, how will society at large benefit from it, and what inducements does it hold out to private adventurers to take it up as a means of investing capital?

"Now, at the outset of nearly all new propositions of this nature, there are two kinds of objections which we have to contend with. The first arises from the circumstance of the invention being a novelty, and different from all that people have previously been accustomed to. We get laughed at; the matter is treated as a dream. 'Really, sir,' says one, 'you cannot be serious in proposing to stop the escape of a thief, or swindler, by so small an electric spark, acting on a needle; if you had talked of sending a thunderbolt, or flash of lightning, after him, I might have thought there was some feasibility in it.' Another tells us that the experiments are very well across a room, but would not succeed on a large scale. Then, as soon as the practicability of the thing is undeniably established, the same people turn upon us with the question, 'What is the use of it?' There must be some present who will recollect that the first introduction of gas was beset with the same objections. So also were the railroads, and to a certain extent they continue to be up to this time. So also was the steam engine, printing; in fact, almost everything new is discountenanced, or coldly received, by the public at large in the first instance. However, the time has, I believe, already arrived, when the practicability of this electric telegraph is no longer doubted, either by scientific men, or by the major part of the public, who have

* To this may now be added (1) a block system for railways, (2) the telephonic relay, and (3) the oxide of manganese (Leclanché) cell, besides numberless suggestions of a more or less practical nature, many of which are described in these pages.

† Referred to in his letter of 16th June, which see *infra*.

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given any attention to the facts upon which the invention rests.

"I have, therefore, to confine my remaining observations to the uses and application of it. And first, I have a few words to say upon what must be considered as a minor application, namely, the purposes it will answer upon a railway, for giving notices of trains, of accident, and stoppages. The numerous accidents which have occurred on railways seem to call for some remedy of the kind; and when future improvements shall have augmented the speed of railway travelling to a velocity which cannot at present be deemed safe, then every aid which science can afford must be called in to promote this object. Now, there is a contrivance, secured by patent,* by which, at every station along the railway line, it may be seen, by mere inspection of a dial, what is the exact situation of the engines running, either towards, or from, that station; and at what speed they are travelling.† Not only this, but if two engines are approaching each other, by any casualty, on the same rails, then, at a distance of a mile or two, a timely notice can be given in each engine, by a sound, or alarum, from which the engineer would be apprised to slacken the speed; or, if the engineer were asleep, or intoxicated, the same action might turn off the steam, independent of his attention, and thus prevent an accident.‡

"I cannot, however, avoid looking at the system of electrical communication between distant places, in a more enlarged way, as a system which will, one of these days, become an especial element in social intercourse. As the railways are already doing, it will tend still further to bring remote places, in effect, near together. If the one may be said to diminish distance, the other may be said to annihilate it altogether, being instantaneous. The finger of the London correspondent is on the finger key; and, anon, in less time than he can remove it, the signal is already on the paper in Edinburgh; and almost as fast as he can touch one key after another in succession, these signals are formed into words and intelligible sentences. These may either have private interpretations attached to them, easily arranged between individuals, or they may be translated according to rule by a clerk of the establishment, supposing such an establishment to be instituted and thrown open to the public like the Post Office, on the principle, that any one might send a communication on paying some moderate fee, to be charged according to length. All the practical details of such an establishment are easily chalked out.

"Now, how far would there be sufficient employment, or business, to remunerate the projectors, and how far would the public at large be benefited? Premising that it is a very shallow supposition to consider it as facilitating monopolies, inasmuch as it would be open to all, the first question is, what would be the cost, or original outlay, on a very complete system? I believe about £100 per mile. That would be £10,000 from London to Birmingham, and about £10,000 more, making £20,000, to bring these towns into communication with Liverpool and Manchester.

"Now, if there be 2,000 miles of railway altogether open, or likely to be open ere long, then the capital requisite to carry such an enterprise generally throughout the kingdom would be £200,000, or about $\frac{1}{15}$ of what has been expended on the London and Birmingham Railway alone. Let us first confine ourselves to the line of communication between the four great towns, London, Liverpool, Manchester, and Birmingham, at an outlay of about £20,000. The repairs, when once laid down, would be very inconsiderable, and very rare. The annual expenses, beyond the interest of the money, would be almost confined to the clerks and superintendents of the establishment, making a total, which, for argument's sake, we will call £2,000, or £3,000 a year. Whence will be the revenues to cover this expense, and leave a profit?

"In the first place, there is a certain amount of staple employment, which would be daily and regular. We should inevitably have to communicate the prices on exchanges, the market prices of commodities, rise and fall in stocks and shares. There would be the earliest information of commercial stoppages, arrival of ships with cargoes, and their departures. Then there would be Lloyd's shipping list, as a matter of course, Government dispatches, and certain portions of banking correspondence and announcements. Lastly, among the best regular customers would be the newspapers. Public curiosity upon events of importance would ensure that the press would generally get the earliest possible information for their readers, and competition alone would oblige it. There are certain events which would be communicated by telegraph to all the principal towns in the kingdom for publication in the newspapers, as regularly as the publishing day or hour came round. There would be Parliamentary divisions, results of elections, public meetings, criminal news, results of trials of general interest, and the earliest foreign news of all kinds. So much for the regular employment.

"But I conceive that the occasional employment of individuals, for private family correspondence, or for purposes of business, would make up in the aggregate even a far greater amount. Here it is quite impossible to see how multifarious may be the occasions on which such a means of rapid communication would be of vital moment. Let any individual reflect whether in the course of his life, whether in the course of the past year, there has not been more than one occasion when he would eagerly have availed himself of it, if it had been in existence? Generally speaking, we know that the post is fast enough, and often letters are sent by private hands, when they are many days delayed, and it is of no consequence. But such occasions there are, and though, for argument's sake, I suppose them rare, yet in reality they are not so. If in the population of London, upon an average, only one private person in eight employed the telegraph only once in six months, and received an answer by the same means, at no higher charge than the present postage, say 1s., here we should have at once a revenue of £40,000 a year, which I take to be infinitely within the mark.

"Now, what are the occasions on which private individuals would prefer the telegraph to the post? Let us say to announce a birth, or marriage, in a family connection, a death, or sudden illness. No one would be satisfied to convey intelligence of such an event to anxious relatives by any other than the most rapid communication, and if the medium was in existence they would be expected to use it. If one death in ten which take place in London were communicated by telegraph, and that to only one person at a distance the amount of income from this single cause alone would exceed £1,000 a year. Announcements of dangerous illnesses, and daily communications thereon, which would often be transmitted, would considerably exceed even that of the deaths. But this is not all; all sorts of family events, besides births, deaths, and marriages, transactions of business, urgent communications between commercial travellers and their principals, errors and oversights to correct before too late, all these would be of no very unfrequent occurrence in every family, or business firm, and taken on the whole, among the great population of this active nation, they would supply the telegraph with as much employment as it could well get through.

"But now some one will say, supposing it all very true that these things can be done, supposing that it will pay very well to speculators, of what advantage will it be to society at large? Railroad travelling is quick enough in all conscience; people used to say that stage coach travelling was quick enough; and some years before that, they were no doubt very well satisfied with the waggons. Now here is a means of communication compared with which the railroad travelling is as a snail's pace. The electrical telegraph can be considered as only one means of facilitating intercourse between distant places; and it is adapted for occasions where all other means would fail. It will in some respects give to persons living at remote distances the same advantages as if

* In the drawing up of the final specification all mention of this invention was, most unaccountably, omitted. This enabled Wheatstone in 1840 to patent a similar step-by-step instrument, with dial face, &c.

† At every railway station there will be a dial, like the face of a clock, on which, by means of a hand, or pointer, it may be seen where any particular train, running, towards, or from, that station, may be at an particular instant. Every time the engine passes a milestone, the pointer on the dial moves forward to the next figure, a sound, or alarum, accompanying each successive movement.—Davy MSS.

‡ The most perfect block system of the present day does not do anything like this.

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they lived in the same street. Should the system ever be adopted generally throughout Europe, what a vast field does it not open to us. Whatever is going on in Turkey, or in Russia, may be known in London the same hour; and, though it may seem a bold speculation, I can see no improbability that this will be realised wherever the line of country admits of it. In fact the greater the distance the more valuable in proportion will be the information communicated.

"Goods ordered from a distant country will, of course, arrive in just half the time they otherwise would, because the outward voyage, or journey, for carrying out the order by letter is dispensed with. On general principles, whatever tends to promote intercourse between distant countries, or distant parts of the same country, will inevitably promote civilisation and increase the comforts of life.

"I must now conclude by stating that the electrical telegraph is already in progress of being established through a considerable line of this country, and there is every encouragement for supposing that it will, without delay, be brought into operation on a still more extended scale. I trust, therefore, that the company present will live long enough to see that, while we have not presumed to use the thunderbolts of Jupiter for destructive ends, we have acquired a command over the same electrical principle, for purposes infinitely more beneficial."

Having now given a full and impartial account of Davy's many and wonderful discoveries in electric telegraphy, it will be interesting to follow him in the steps which he took to get his inventions adopted. For this purpose we must turn to another class of his MSS, viz:, his private letters to members of his family, and chiefly, to his father, Mr. Thomas Davy, Surgeon, of Ottery St Mary. In the extracts which we shall give from these the reader, who knows anything of the similar negociations of Cooke and Wheatstone during the same period, will find some startling revelations.

At one time his inventions were on the point of being adopted by more than one English Railway, and, had he stood his ground but six months longer, there can be no doubt that he would have eclipsed his rivals, so that to-day we should hear more of Edward Davy and somewhat less of Cooke and Wheatstone, But alas! just as his labours seemed on the point of fruition, private affairs, which we can never cease to deplore, drove him from England, and, of course, left his rivals an easy triumph, Davy sailed from the Thames for Australia, on April 15, 1839, and, amid the new cares of a somewhat unsettled Colonial life, soon forgot all about the telegraph. Indeed we believe that nobody will read our memoir with more surprise than the old man himself who is the subject of it.

The first extracts that we shall give have reference to the Exhibition at Exeter Hall, referred to on page 185 of this Journal. In a letter to his father dated January 23, 1838, he says:—

"I write you a few lines in haste, upon a different subject from the last. By the advice of several friends, whom I have deemed trustworthy counsellors in such matters, I have been induced to open an exhibition of my electrical telegraph, accompanied with electrical and galvanic experiments of a somewhat novel nature to illustrate its principle.* You will observe that the present apparatus is, in appearance and effect, totally different from what you have seen, though founded on similar elementary principles.

"The degree of success of the last three days has been sufficient to encourage me in the correctness of what I have done. I have had Captain Beaufort from the Admiralty to look at it, as well as Mr. Jay, who is superintendent of the Government telegraphs, and who invited me to the Admiralty to-morrow, to examine the telegraphic arrangements, and furnish me with an exact estimate of the expenses of the present system for the sake of comparison. This I think a good introduction. To-day I have had 18 persons, paying their 1s. each, and yesterday 12, to see it, several expressing themselves gratified, and saying that they should bring their friends to see it. An old gentleman came yesterday, and to-day he came again with four ladies. He says he is coming again to-morrow with some male friends and others.

"On the principle, *parvis componere magna*, I am led to presume that if the thing were generally known (instead of being merely left to the attraction of a board or two at the door) a great many persons would come to see it, paying their 1s. each, and that thus I might realise a considerable sum [which would be] very acceptable. To make it pretty generally known is impossible without some expense which, at present, it is out of my power sufficiently to compass. And yet the thing appears to me so promising in success, that I would not willingly lose the chance, after having bestowed so much care, anxiety, and labour on the invention, and having, as I have now the best reason to believe, brought it to greater perfection than any other person. It is my anxious wish, now that every principal expense has already been met, immediately to advertise the exhibition, once or more, in every principal newspaper, and to take other necessary means of making it public. From present experience I believe the returns will be speedy, and in any case the prospect of indirect advantage to me is sufficient to justify so doing. If I neglect, or am unable to avail myself of, the present opportunity, there are others ready who will instantly take it up.

"Clarke, Palmer, and Cooke himself have been to see it at the private exhibition on Thursday last, and though they could not *immediately* make out the principle on which the effects were produced, yet it is all come-at-able by dint of pondering and patient experiment by such long-headed persons.

* * * * *

"From 11 to 5, exhibition hours, I have scarcely had time to warm my fingers in the late bitter weather, from the all-sorts of questions, explanations, illustrations, demonstrations, &c., I have had to deal forth to the learned and unlearned—the former being the least troublesome."

A few days later he wrote to the same address:—"The exhibition to-day had about the same number of visitors within 2 or 3, which, all things considered, is pretty well, and, if continued, would set aside all apprehension of losing by it.

* * * * *

"Among the visitors were Lord Euston and his son, who were pointed out to me by a gentleman present. Mr. James Wheeler, my old master's brother, was there. He was at a lecture at the Royal Institution last week, when Cooke and Wheatstone's telegraph was exhibited, and said that, on comparison of action and effect, he much preferred mine. He also said that theirs would be rather advantageous to me than otherwise, as the public would soon draw the parallel.

"It is my earnest desire now to make the thing promptly known in every direction [by advertising largely].

* * * * *

I calculate that by the time 1,000 persons have been to see the telegraph their retail conversation will be enough to dispense with other advertisements than rare and occasional ones, because, out of 1,000 persons on an average computation, 100, by their gossipping propensities, will act as walking advertisements.

"I have with me a boy who is remarkably sharp and handy at repeating the experiments. * * * * The little fellow appears to be able to understand anything he has once seen, and has, moreover, a very good address, asking for the One Shilling, Sir, or Madam, very genteely, &c.

"You did not expect to have a son turn showman, but I trust I am merely instrumental in promulgating a useful discovery, and that you will live to see it established, generally, throughout the country. I must *endeavour* to persuade the Admiralty to lay it down from London to Chelsea, or Putney, for experiment, this being the most foggy part of the line towards Portsmouth; but I fear they are too stingy of the revenues of the nation. I rather expect that some enter-

* "This exhibition is accompanied with a variety of interesting experiments, the room *lighted by an enormous galvanic battery*, and, altogether, I have seldom passed an hour more amused." Extract from letter in *Mechanics' Magazine*, for February 3, 1838, p. 296.

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prising individuals will take it up for public use. Time will show.

"P.S.—Receipts to-day about 25s. Among the visitors was pointed out, after he had left the room, Earl Grosvenor."

Towards the end of February, 1838, he wrote :—

My Dear Father,

My business with Mr. Welch is concluded—my lease cancelled—and I am no longer the occupier of the house 390, Strand. Please, therefore, address to me at Mr. Smith's, 199, Fleet-street.

* * * * *

As we some months ago prognosticated, the telegraph, being once promulgated, has interested the public, and is in a fair way to be generally adopted. The Great Western Railway have decided upon laying it down upon their line, and the only question, both in this, and in all subsequent cases, will be, whether my plan, or that of Cooke and Wheatstone, be preferred.

Mr. Brunel, Junior, Engineer to the Great Western Railway, with Mr. Tite, and other Directors of the company, came to see my apparatus, and wished me distinctly to point out the advantages which it possessed over the rival scheme. Mr. Brunel, being on intimate terms with Mr. Cooke, was somewhat inclined to lean the other way, but the principal difficulty under which I laboured was the impossibility of rendering manifest all the advantages of my mechanism, without entering, more or less, into such explanations as would, more or less, betray my secret—as yet unpatented. When, therefore, I stated that I could effect such and such objects he could not see how it was possible—thought the attempt would be dangerous, or precarious. Seeing also that I employed six wires he could not conceive but that my plan must be an infringement upon the patent of Cooke and Wheatstone, and that the company could not safely carry it into execution without risk of action for damages, &c.

Moreover, that, as I was not prepared fully to develope my plans, I could not be considered in a condition to treat with them, for they would have to buy of me what he designated "a pig in a poke," which, though it might produce very pretty effects, yet, as the *rationale* was not open for canvass, its practicability could not fairly be judged of, nor could he confidently assure the company but that it might prove to be an infringement on the others' patent. Mr. Brunel is a particularly sharp, intelligent man, capable of comprehending anything in all its bearings, and of improving the barest hint. I had, of course, to be on the alert to divulge nothing that would impair the security of a future patent-right. I could not fail to learn something from him, and the result of this interview has been to prove to me the necessity of ascertaining, with the greatest care, the precise footing upon which I stand, before taking any further steps. I have endeavoured to persuade the company to delay a week, or two, before they ultimately decide on adopting any plan.

In the meantime, my first object will be to obtain the opinion of the most eminent lawyer in patent affairs, and I have been nearly all this day engaged in conference with Mr. Carpmael upon the subject. This may cost me two or three guineas, but will be infinitely cheaper than a blindfold course of proceeding. To-morrow I shall get his opinion. Should this be favourable to my views, I shall almost think it right to obtain a second opinion of some eminent barrister, or of the Attorney, or Solicitor-General, before venturing to act upon it. But if fully confirmed as to my right to secure as exclusive, and to act upon, or license others to act upon, my own invention, there can be little question as to the peremptory necessity for immediately raising funds to take out a patent, which will place me on a par, or more than a par, with Cooke and Wheatstone. The time has now arrived when the thing is on the point of being acted upon throughout Europe.

As to the particulars of my mechanism, there are guesses enough at it, but, though it is simple as can be, the guesses are as far wide of the actual truth as need be. Mr. Cooke himself is in perfect ignorance of it.*

I hope, in a postcript, to subjoin Mr. Carpmael's opinion. He told me this evening that, though he would not record it on paper until he had investigated the matter fully, yet his present impression was that the two inventions [*i.e.*, Cooke and Wheatstone's and his own] differed most essentially in all main points, and that a separate patent might be obtained and maintained without hazard of litigation. He has appointed to-morrow morning to inspect my mechanism (of which as yet he has seen the description only) at 10 o'clock, at Exeter Hall.

28 February, 1838: I enclose a copy of Mr. Carpmael's opinion.† I am now passing the patent through the first stage, which will cost about £12, but beyond this, unassisted, I shall not be able to go. Mr. Carpmael thinks it may not be difficult to get some one to advance money for future patents, if I can only place myself in a condition to explain, by securing the English patent first, after which it will be just as desirable to do the same thing in Belgium, America, and other places.

* * * * *

Your ever affectionate son,

E. Davy.

My Dear Father: This long-pending decision upon my application for a patent has at length been given. I believe I told you that, owing to the Solicitor-General not being able fully to comprehend some points, it had been agreed to call in the assistance of some eminent scientific man, and, accordingly, Mr. Faraday was referred to as being the highest electrical authority in the kingdom, and he was kind enough to undertake [the examination of the points in question]. The result has been in my favour, *i.e.*, I am entitled to the patent I am applying for with the retention of every point of the least value. The Solicitor-General's report will be ready for delivery to-morrow, Thursday, and then all that will be wanted to proceed with the patent will be the money. It will then take about ten days to pass the great seal, and until that there is no security for it, and I will still labour under the difficulty of not being able to explain its nature, or advantages, to any one so as to get it taken up. Besides, there is every day the risk of persons finding out the particulars for themselves.

Once the patent secured, I think it not improbable that it may end in a compromise with Cooke and Co.,‡ for when I have the patent I must get connected with some one possessed of capital. They have, I understand, already laid out £2,000 upon their telegraph, and are very anxious at present, as Mr. Wheatstone told me they were in treaty with some of the great railway companies, but that the latter delayed coming to a decision, understanding that there might probably be another patent in the market. So, if I pass my patent, they will either have to wait six months to see the specification, or else offer me terms at once.

Whether the Great Western is the company alluded to I know not, but I had previously been given to understand by Mr. Gibbs that they had already contracted with them, and were going on with the preparations (as I was told by a a different party) of coating an immense quantity of copper wire with india-rubber. It may, therefore, or may not, be some other great company.

I am happy in being able to communicate the intelligence contained in this note, for, from the long and vexatious delay, I have been not without apprehension that the decision would be against me. The circumstance of Mr. Faraday having been called in will also render the patent safer, as his opinions

* "I have sufficient reason to know that the true principle of [my apparatus] has not been discovered by anyone, not even by Mr. Wheatstone. I have purposely, and for a veil, allowed it to be supposed that the principle is the same as that in Mr. Cooke's invention, which, as I designed, is taken for granted." Davy MSS.

† This document, copied by Davy himself, is preserved amongst his MSS. It bears the date February 24, 1838.

‡ This is what exactly did happen eventually—the patent was bought up for £600 by the old Electric Telegraph Company, and smothered, like a good many others.—See letter of May 12, 1847, amongst the Davy MSS.

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on such matters would naturally be looked upon by the public with some confidence.

* * * * *

With kindest loves, believe me,
My dear Father,
Your ever affectionate Son,
E. DAVY.

30 May, 1838.

P.S.—I enclose a copy of the claims upon which Mr. Faraday advised that my patent might be granted. You will perceive that it contains the most important points.*

(TO BE CONTINUED.)

ON THE PENTANE STANDARD, AND ON A NEW FORM OF PHOTOMETER.†

BY A. G. VERNON HARCOURT, M.A., F.R.S.

(CONCLUDED FROM PAGE 189.)

Early in the present year the attention of the Metropolitan gas referees was called by Mr. Wates, the engineer in charge of the Vauxhall station of the South Metropolitan Gas Company, to a persistent difference between the return of the illuminating power of the gas from the testing place at Clapham and the testings of the same gas at Kennington, where it is stored. To gain further evidence, a set of testings was made alternately and in quick succession by the same observers at the gasholder station and at the testing place. The testings were made with a jet photometer and a pair of candles carried backwards and forwards. The results with the candles, obtained with the greatest care, were too discordant to be of much value; but both they and the more trustworthy indications of the jet photometer confirmed the former experience.

The planning of these testings suggested the desirability of giving to the pentane standard a portable form. In this form the flame is still an air-gas flame produced by mixing in the reservoir of the lamp the vapour of pentane with air. The mixture, being heavier than air, floats over the liquid; its composition varying in each layer from a very rich gas, at the surface of the pentane, to air into which little or no pentane has diffused, beneath the lid. It is clear that by tapping this stratified mixture of gases at the proper level an air gas containing 3 volumes of air to 1 of pentane—the same that is made up in the gasholder—may be drawn off; the same mixture being constantly produced at the same level by evaporation and diffusion of pentane vapour from below, and inflow of air from above. With a reservoir and outlet as small relatively to the flow of gas as have here been made, if the gas were visible a whirlpool would be seen, the separate threads of air and pentane not blending entirely until they have been drawn into the pipe. But no matter how the gases enter, the mixture becomes perfect before their journey is ended; and the length and minimum diameter of the pipe having been once duly adjusted, the composition of the mixture, when a $2\frac{1}{2}$ inch flame is burning, remains as constant as though the gases had been previously measured and mixed in a holder.

The rate of flow of the gas depends upon the height of the pipe within the reservoir above the surface of the burner, the size of the hole drilled through a plug which blocks the pipe at one point, and the density of the mixed gases. Any three of the four quantities above named being kept constant, the fourth will be constant. Thus the dimensions of the pipe and hole having been fixed, if the density of the gas is constant the rate of flow will be constant; and equally—and this is the principle of the lamp—if the rate of flow is kept constant by setting the height of the flame, the mixture will be the same. It will be seen that the height of the flame furnishes a very delicate test of the rate of flow and of the quality of the gas. For if the gas flows more quickly, the cause must be that it is denser, by having a larger proportion of pentane, and consequently also richer. Both the increased flow and the increased richness make the flame longer. On the other hand, if from any cause the gas entering the pipe is below the standard quality, this will make the flame shorter, both from the causes which operate in the jet photometer, and also because the lower density will diminish the rate at which the gas passes to the burner. The permanent adjustment of the length of pipe and size of hole was made by repeated trials until the flame of the lamp gave exactly as much light as the standard flame. This having been done, similar lamps can readily be produced by measurement.

The height above the surface of the pentane at which the standard gas is to be drawn off varies with the temperature, and therefore needs to be adjusted on each occasion and from time to time. It is convenient to have the means of making this adjustment without exposing the eyes to more light than falls upon them when observing (through a hole in a screen) whether the tip of the flame touches the wire above. The arrangement for this purpose consists of an india-rubber ball filled with water, and connected by a flexible tube with the bottom of the reservoir. By pressing upon the ball with a screw, the water can be raised to any required level in the reservoir; the pentane, supplied drop by drop at about the rate at which it is consumed, floats on the surface of the water. So much heat is absorbed by the evaporation of the pentane that a constant supply of heat is necessary. Such a constant supply is readily obtained by fastening to the reservoir a stout copper wire, which supports a copper disc over the flame. The height and inclination of the disc above the flame may be altered from time to time according to the temperature of the room in which the lamp is used. A glass, T, which connects with the reservoir the supplies of water and of pentane, serves also as a gauge to tell the height of the liquids within the reservoir. A stopcock and bulb beneath the T serve to shut in and keep the small quantity of pentane which is in the reservoir at the end of a testing.

It remains to describe briefly a new form of photometer which has been in use in Oxford for two years. The office of the gas referees has been supplied with one by Mr. Hartley, and Mr. Sugg has been kind enough to send another here to illustrate the present paper. The type is that of Count Rumford's shadow photometer. As in the French system arranged by Foucault, the observer is screened from the direct light of the flames, and looks upon transmitted shadows or half-lights, the chief peculiarity of this arrangement being that the surface which is illuminated by the standard flame is flanked on both sides by similar surfaces illuminated by the more distant gas flame. Through a brass plate in which two similar rectangular slots have been cut at a distance equal to their width, the light from the more distant burner falls on both sides, but not on the centre of a small paper screen, while the light of the nearer standard flame falls only on the centre. It is found that a good judgment can easily be made of the point when the whole of the paper is equally illuminated. For ordinary testing of gas, both burners occupy fixed positions; the standard flame is set at exactly 1ft. from the centre of the screen, and the London argand at 4ft.—the one being 2in., and the other 8in. from a line perpendicular to the screen. The height of the standard flame having been adjusted by looking at its tip only and the wire above through a small opening in the curtain, the tester moves the stopcock, which regulates the supply of coal gas till the illumination of the translucent screen is uniform. He then reads the meter when the minute clock strikes, and again two minutes afterwards. The gain or loss of the meter gives the rate of the gas rather more accurately than a reading after one minute. A table has been constructed on which the corrected illuminating power of the gas can be read off directly by referring to the tabular number, or reading of the aërorthometer at the head of the columns of figures, and finding the line corresponding to the observed gain or loss of the meter in two minutes. No longer description need be given, for an examination of the photometer itself will make its principle and construction clearer than is possible by the fullest account of them.

Three defects in the present system of photometry, apart

* This document is preserved amongst the Davy MSS.

† A paper read before the Gas Institute.

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from the standard employed, seem to be avoided in the proposed arrangement. First, the placing of the lights to be compared on opposite sides of the illuminated disc raises a difficulty as to the precautions which it is proper to take for the exclusion of extraneous light, or light reflected from the back or sides of the photometer, or, it is said, from the surrounding air. When both lights are on the same side of the illuminated screen, the exclusion of diffused light, whether derived from the sources of light to be compared or elsewhere, is not essential. Darkening of the room in which the photometer stands is desirable only because it makes the eyes more sensitive. Secondly, when the gas has to be regulated to burn at five cubic feet per hour, and the distances have then to be observed at which the two sources of light illuminate the disc equally, two adjustments have to be made where only one is needful. The one condition that, from the nature of the case, must be adjusted at each testing, is the rate at which the gas is to be burnt. In the proposed form of photometer the distances are fixed, and can be verified at any moment by means of a 1-foot and a 4-foot rod; and the only adjustment needing to be made at the time of the testing is that on which the result depends—viz., the adjustment of the rate of the gas so as to produce equal illumination. Thirdly, the London argand, when supplied with less than 5 cubic feet per hour of 16-candle gas, falls off in its yield of light to a degree much greater than corresponds to the falling off in the quantity or quality of the gas, or than a flat-flame burner would show. But a slight falling off in the quality of the gas is not thus exaggerated when this burner is always made to give the light of 16 candles—gas being supplied at the requisite rate. If gas is supplied at sufficient pressure, gas consumers can always get as much light as usual. The way in which they are affected when gas is supplied of lower quality is that they need to burn and pay for more gas. Thus the system to which the new photometer is adapted—of measuring the rate of consumption which yields, with the sample of gas under trial, the light of 16 candles, and inferring thence the illuminating value of the gas—has the advantages of not exaggerating any deficiency in the gas, and of measuring directly that quality of the gas which affects the consumer.

The light of one candle seen in daylight and from a distance appears insignificant; and the remark is frequently made that for measuring powerful sources of light a more powerful standard is desirable. The remark appears to arise from a confusion between light and illumination. Our unit of light is a candle; our unit of illumination should be the illumination caused by one candle at the distance of 1ft. This illumination is as good for the eyes, for reading, or any ordinary purpose, as a stronger illumination; and the eye can judge of this illumination, when comparing one with another, quite as well as of stronger illuminations. If in photometry the disc or standard of light is to move about, and the distance between them be read, 1ft. is rather too short a distance. Small errors of reading or in the working of the apparatus become material. But if the distance is fixed, there is no difficulty in setting a disc or screen and the centre of a burner 1ft. apart with an error not exceeding a few hundredths of an inch; and if a powerful light is to be measured, a moderate-sized room will allow of placing the large burner 20ft. off, which is sufficient for a 400-candle burner. The brilliant light given by the large Siemens burners has been measured in this manner.

ON THE CHEMICAL CORROSION OF CATHODES.*

BY G. GORE, LL.D., F.R.S.

In a paper published in Vol III., p. 36, of the *Proceedings of the Birmingham Philosophical Society*, I stated that "Both common and electro-copper, when used as a cathode, dissolved chemically faster than the same copper without a current;" also that "In the cold liquid† common copper dissolved 2·26 times faster, and electro-copper 2·00 times faster as a cathode than without a current," and "in the hot liquid common copper dissolved chemically 1·39 time faster, and electro-copper 1·07 time faster as a cathode than without a current."

In order to ascertain whether this was a uniform result, I made some experiments of a similar kind with other metals and liquids.

PRELIMINARY EXPERIMENTS.

Experiment 1.—I took twelve similar narrow glass vessels, each containing 3½ ounces by measure of liquid: A and A′ contained a mixture of eight measures of water* and three of pure sulphuric acid; B and B′ six measures of water and one of pure hydrochloric acid; C and C′, two measures of water and one of the same acid; D and D′, the same mixture; E and E′, thirty-two measures of water and one of pure sulphuric acid; F and F′, each containing 3½ ounces of water, and 175 grains of cyanide of potassium.† The metals employed were: For all the anodes, except that in F, sheets of platinum, and for that in F a sheet of steel; I also took for a cathode and comparison sheet two perfectly similar pieces, one inch wide,‡ of the same metal for each liquid; for A and A′ two pieces cut from the same sheet of rolled nickel known as "Fleitmann's," containing a small proportion of zinc alloyed with it to render it ductile; for B and B′, similar to those in A and A′; for C and C′, two sheets of extremely pure tin, cut from the same piece; for D and D′, two sheets of electro-deposited copper cut from the same piece; for E and E′ two sheets of highly carbonised steel cut from the same piece;§ and for F and F′ two sheets of pure silver cut from the same piece. All the cathodes and comparison sheets were perfectly cleaned, then weighed, and immersed at the same time in a vertical position, and to the same depth (usually 2¼in.) in their respective liquids; and the latter were all maintained at the atmospheric temperature (about 16° C.) during the whole of the experiment. The electric current employed was from a series of four Smee cells, and was passed through the six vessels in single series, the current commencing from the time of immersion of the metals. The two pieces of steel and their vessels E and E′ were removed from the series at the end of seven hours in consequence of greater rapidity of corrosion. The cathodes and comparison sheets of tin, copper, and silver in vessels C and C′, D and E′, and in F and F′, were removed at the end of twenty-four hours, and those of nickel in vessels A and A′ and B and B′ were removed after thirty hours of action. No gas was visible upon the copper in D during the experiment. The following are the losses suffered by the several cathodes, and the corresponding comparison sheets:—

		Losses in Grains.
A	Nickel cathode in dilute sulphuric acid ...	·077
A′	„ comparison sheet „	·092
Proportion of loss, 85·7 to 100 = a protective effect of 16·3 per cent.		
B	Nickel cathode in dilute hydrochloric acid.	·157
B′	„ comparison sheet „	·197
Proportion of loss, 79·69 to 100 = a protective effect of 20·31 per cent.		
C	Tin cathode in dilute hydrochloric acid ...	5·441
C′	„ comparison sheet „	4·793
Proportion of loss, 113·5 to 100 = a corrosive effect of 13·5 per cent.		
D	Copper cathode in dilute hydrochloric acid	·465
D′	„ comparison sheet „	·202
Proportion of loss, 230·2 to 100 = a corrosive effect of 130·2 per cent.		

* From the *Proceedings of the Birmingham Philosophical Society*.

† The "liquid" was "a mixture of ten volumes of distilled water and three of pure sulphuric acid."

* Distilled water was used in all cases.

† This sample of cyanide was found by analysis to contain 86·65 per cent. of actual cyanide. Samples of the purest commercial cyanide of potassium appear to contain traces of sulphide, probably derived from sulphate deoxidised during the process of fusion.

‡ All the cathodes and comparison sheets were one inch wide. This width of electrode was used in all subsequent experiments, unless otherwise stated.

§ The comparison sheet of these two had been heated to redness before the trial, and this may have effected the speed of corrosion.

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	Losses in Grains.
E Steel cathode in dilute sulphuric acid	2·550
E′ „ comparison sheet „	4·050

Proportion of loss, 62·96 to 100 = a protective effect of 37·04 per cent.

F Silver cathode in a solution of potassic cyanide	1·815
F′ Silver comparison sheet of potassic cyanide	1·832

Proportion of loss, 99·06 to 100 = a protective effect of ·94 per cent.

Remarks and Conclusions.—The results in these preliminary experiments indicate that in some cases the chemical corrosion of a metal is increased, and in others decreased, by making the metal a cathode. Other causes, such as capillary action, minute differences in the surfaces of the plates, &c., however, operate.

Experiment 2.—Two sheets of nickel were again compared in a mixture of equal measures of hydrochloric acid and water; and two of tin were also compared in a mixture of one volume of hydrochloric acid and 1½ volume of water, a current from two Smee cells being passed into the nickel cathode, and a separate similar current passed through the tin one, each during 16 hours. The nickel cathode was then covered with a thin film of black powder, and gas was rising from its surface; the comparison sheet exhibited similar phenomena, but only in a very minute degree. The sheets of tin also were covered with minute adhering bubbles of gas; larger in quantity upon the cathode than upon the comparison sheet. After removal of adhering powders

The nickel cathode had lost	1·489 grain.
„ „ comparison sheet had lost...	·172 „

Proportion of loss, 865·7 to 100 = a corrosive effect of 765·7 per cent.

The tin cathode had lost	2·500 grains.
„ comparison sheet had lost	2·810 „

Proportion of loss, 88·96 to 100 = a protective effect of 11·04 per cent.

Remarks and Conclusions.—On comparing the results with those obtained with the same metals in Experiment 1, we find that with a somewhat less dilute acid the effects with tin were reversed, also that with a much stronger mixture of acid, and a stronger electric current, instead of the nickel cathode being somewhat less corroded than the comparison sheet, it was corroded 8·6 times as much. This might in chief part be accounted for by the liberation of gas and electrolysis of the liquid stirring up the solution, and somewhat by liberated solid impurity causing local action.

It is manifest that if gas is set free at the surface of the plates, and remains adhering to them, it must diminish the amount of corrosion, and that if it rises to the surface it must move the liquid and bring fresh particles of it into contact with the plate and increase the corrosion. These effects of ordinary chemical action are of course liable to occur both in the current cell and in the comparison one; and, in addition, gas may also be evolved by electrolysis in the current cell, and thus alter, either by increasing or decreasing, the amount of such corrosion. It is manifest also that any impurity in the metal must affect the results in several ways, which may differ with the nature of the impurity. If the material were an insoluble solid it would be liberated and adhere to the metallic surface, and if it were electro-negative it would form with the metal a voltaic couple and increase the corrosion, and each of these circumstances must be taken into account. The loss of weight by removal of the insoluble matter is also an element in the case, but with nickel in dilute hydrochloric acid that amount was small. An electric current may increase the corrosion of a cathode by depositing upon it a film of any less positive metal which may happen to be present as a soluble impurity, and this may account for the great acceleration of corrosion of the nickel cathode; it might also account for some of the variations in the effect of the current with copper.

The foregoing and the following experiments show that the loss of weight of a cathode in an electrolyte is dependent upon several conditions, such as difference of metal, of liquid, or of strength of liquid, some of which tend to increase, and others to decrease the corrosion.

No further experiments were made with nickel, in consequence of its impurity.

Experiment 3.—Two perfectly similar sheets of iron were compared in two portions of a mixture of one volume of hydrochloric acid and seventy-two volumes of water, a current from two Smee cells being employed, and the experiment continued 6½ hours. Both sheets evolved a very small amount of gas, but remained clean and bright.

The cathode lost	·305 grain.
The comparison sheet lost	·480 „

Proportion of loss, 62·5 to 100 = a protective effect of 37·5 per cent.

Remarks.—The cathode lost the least. This result agrees with that obtained with steel in dilute sulphuric acid, and the proportion of loss of cathode to comparison sheet was about the same in each case.

Experiment 4.—The same two sheets of copper used in Experiment 1 were now compared in a mixture of two measures of hydrochloric acid and one of water, with a current from two Smee cells, continued 19½ hours. A few small bubbles of gas appeared on the cathode. Both portions of liquid became yellow, but the electrolyte the most so, probably in consequence of liberation of chlorine by electrolysis.

The cathode lost	·114 grain.
The comparison sheet lost	·535 „

Proportion of loss, 21·3 to 100 = a protective effect of 78·7 per cent.

Remarks and Conclusions.—In this case the comparison sheet was much the most corroded. The result is opposite to that obtained with the same pieces of copper in a mixture of two volumes of water and one of hydrocheric acid, in Experiment 1.

Experiment 5.—The object of this experiment was to compare with the last one for influence of difference of strength of electric current. The copper plates were as similar as possible to those used in that instance. The acid mixture was also of the same strength. The current was from a single cell, and continued 19½ hours.

The cathode lost	·495 grain.
The comparison sheet lost	·521 „

Proportion of loss, 95·15 to 100 = a protective effect of 4·85 per cent.

Remarks and Conclusions.—In this case also the comparison sheet was (though to a small extent only) the most corroded. The stronger current in the previous experiment appeared to have a greater effect in diminishing the chemical corrosion.

The following experiment is a usual example of the behaviour of a silver cathode in a solution of potassic cyanide.

Experiment 6.—Two plates of pure silver one inch wide and four inches long were immersed 2½ inches deep, each in separate portions of three ounces of water containing 300 grains of potassic cyanide (sample "a"); and a current from two Smee cells passed through one of the portions by means of an anode of sheet iron* of similar dimensions and amount of immersed surface. No gas was perceptibly evolved, or silver deposited. After 22½ hours' action at the atmospheric temperature,

	Grains.	Grain.
The cathode had lost	·759 =	·0337 per hour.
„ comparison sheet had lost...	2·210 =	·0977 „

Proportion of loss, 34·34 to 100 = a protective influence of 65·66 per cent.

The electrolyte now contained ·759 grains of dissolved silver.
The comparison liquid now „ 2·210 „ „ „

Remarks and Conclusions.—The current protected in a conspicuous degree the cathode from corrosion, without at the same time depositing any silver. The results also show that

* Anodes of iron were alone used in solutions of potassic cyanide until it was found that they slightly dissolved; platinum ones were subsequently employed.

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the electric current from two Smee elements does not deposit silver upon a cathode exposing $2\frac{1}{2}$ square inches of front surface from a liquid containing ·759 grain of silver dissolved in a solution of 300 grains of cyanide of potassium of 86·65 per cent. and three ounces of water. From the sufficient continuance of the experiment, the small amount of silver dissolved from the cathode in comparison with the much larger amount dissolved from the comparison sheet, it is very probable that the conditions of the electrolyte and current had arrived at what may be termed a "balanced" state—*i.e.*, a state in which metal is neither dissolved from, nor deposited upon, the cathode.

Want of uniformity of result was usually greater with other metals than with silver, probably in consequence of the metals being less pure and more easily oxidised ; tin might perhaps prove an exception to this.

INFLUENCE OF STRENGTH OF ACID.

Experiment 7.—To ascertain the influence of the strength of hydrochloric acid, a mixture of one volume of water and two of that acid was put into one glass, and two volumes of water and one of the acid in a second glass. Each glass also contained an anode of platinum and a cathode of electro copper one inch wide, immersed $2\frac{3}{8}$in. in the liquid. The two vessels were connected in series, and the current from four cells passed through them during $19\frac{1}{2}$ hours. Two other glasses contained similar liquids and metal plates for comparison. The following were the alterations in weight:—

Stronger Mixture.

The cathode gained	·002 grain.
The comparison sheet lost	·283 „

Weaker Mixture.

The cathode lost	·003 grain.
The comparison sheet lost	·227 „

Remarks and Conclusions.—The strong current diminished the amount of corrosion greatly in both cases, and most in the stronger mixture.

Experiment 8.—The influence of strength of sulphuric acid was also tested with three copper cathodes (and platinum anodes) in three glasses in single series. The first glass contained a mixture of one volume of sulphuric acid and two of water; the second, one volume of that acid and twenty of water; and the third, one volume of acid and forty of water. The current from four Smee cells, in single series, was passed through the vessels during eighteen hours. Three separate glasses contained similar mixtures and comparison plates. The following were the alterations of weight:—

	Grain.
Cathode in 1 vol. of acid and 2 of water lost..	·045
Comparison sheet „ „ „	·062

Proportion of loss, 72·6 to 100 = a protective effect of 27·4 per cent.

Cathode in 1 vol. of acid and 20 of water lost	·123
Comparison sheet „ „ „	·121

Proportion of loss, 101·65 to 100 = a corrosive effect of 1·65 per cent.

Cathode in 1 vol. of acid and 40 of water lost	·093
Comparison sheet „ „ „	·120

Proportion of loss, 77·5 to 100 = a protective effect of 22·5 per cent.

Remarks.—By comparing these results with the ones obtained with copper in dilute hydrochloric acid, it appears that the influence of the current upon the corrosive action is much greater in dilute hydrochloric acid than in dilute sulphuric acid.

The considerable variations in the results indicate that several influences operate to affect the rate of corrosion, and that it would require an extensive research in order to determine even in a few cases what the proportions are in which those influences participate indroducing the effect.

INFLUENCE OF CAPILLARY ACTION.

One of the circumstances which affected the corrosion was capillary action, a description of which is contained in another paper on "The Electrolytic Balance of Chemical Corrosion."

UNEQUAL CORRODIBILITY OF THE METAL.

Another circumstance which disturbed all the results was the extreme difficulty of obtaining pieces of metal which corroded equally. The following experiments illustrate this :—

Experiment 9.—Two pieces, A and B, each $2\frac{1}{4}$in. long and 1in. wide, were cut from contiguous parts of a sheet of pure silver, then cleaned very carefully and immersed at the same time to an equal depth—$2\frac{3}{8}$in.—nearly vertically, in a single portion of a solution of 75 grains of potassic cyanide (sample "a") in three ounces of water, during fifteen hours at atmospheric temperature

Plate A lost	·992 = ·0661	grain per hour.
Plate B lost	1·698 = ·1132	„ „
Difference	·706 = ·047	„ „

After a second immersion during five hours

Plate A lost	·645 = ·1290	grain per hour.
Plate B lost	·691 = ·1382	„ „
Difference	·046 = ·0092	„ „

After a third immersion during three hours

Plate A lost	·357 = ·1190	grain per hour.
Plate B lost	·385 = ·1283	„ „
Difference	·028 = ·0093	„ „

Remarks.—The difference of rate of corrosion, which was great at first, diminished considerably in the case of re-immersion. The influence of the difference of rate of ordinary chemical corrosion under apparently the same conditions affected more or less the whole of the results of this research, and was largely unavoidable.

(TO BE CONTINUED.)

THE EASTERN TELEGRAPH COMPANY (LIMITED).

The twenty-second half-yearly general meeting of this Company was held on the 12th inst., at the Cannon-street Hotel, under the presidency of John Pender, Esq., M.P.

The SECRETARY (Mr. George Draper) read the notice convening the meeting and the minutes of the last meeting, which were confirmed by the present one. The report of the directors, of which an abstract has appeared in *The Electrician*, was taken as read.

The CHAIRMAN said that the revenue for the past six months to the 31st March last had been £328,404, being an increase of £6,595 over the corresponding period of 1882. To earn this increased amount of money, it was necessary to keep open the communications with Egypt at any cost. On this exceptional account they spent over £62,000, employing no less than six ships. Some of the expenses were charged against the September half year, but many of the items they incurred before the September half appeared in the present account. Everything had now been charged, and he thought the result must be considered very satisfactory. The South African Company, of which this Company held almost all the shares, paid them 8 per cent., as compared with 10 per cent., the reduction being owing to the cessation of hostilities. He trusted that they would grow from the 8 per cent. in future through the commercial prosperity of the country, and not through the operations of war. The ordinary expenses of the Company had been £87,827, being an increase of £12,686. After going through the items, and stating that the increase was not of a permanent nature, he observed that the working expenses at the stations also showed an increase of £8,863, owing to the opening of six new stations. After meeting all the additional charges, they were enabled to pay a dividend and bonus together equal to 6 per cent. for the year, as compared with $5\frac{1}{2}$ per cent., and also to carry £85,000 to the general reserve fund, as compared with £75,000 in 1882. The undoubted services which they had rendered to the Government in connection with the war in Egypt had given them a most important position, not only with the British Government, but with other Governments. The consequence of this had been that they had been approached by the French Government, who were engaged in a war in the far East, and who saw the advantage of the services rendered by the Company in the Egyptian expedition, with the result that he believed at the present moment a convention was signed by the French Government enabling the telegraph system to be carried from Saigon to Tonquin. That would be an additional feeder to their system. Since their last meeting they had also laid down a triplicate line in the Red Sea from Suez to Aden, which would prevent any further complaint from the Cape people. He congratulated them on the fact (which he had not been able to do since 1879) that they had not at the present moment one of their ships employed, all their cables being in good working order. The line which they had laid along the Suez Canal through an arrangement they made with the Suez Canal Company had only been opened about twenty-four hours when the Eastern Company's landline through Egypt was run into by a railway train, and, but for this new line, which was only opened in the nick of time, they would have had a very serious loss. He thought that the Company might claim to be a very important factor in the great success which had attended the Suez Canal, for the submarine telegraph was almost the beginning of every operation that took place in the East

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and he might almost say the end of the operation also. He had often spoken of a submarine cable being a very speculative property, but seventeen years experience had satisfied them that it was about as good a property as railway property, for they knew where a break occurred and could repair it. He therefore thought that the debenture stock which they were offering to the public was to be regarded as a thoroughly safe and sound investment. The stock would be required for redeeming debentures falling due next October, and in connection with other capital purposes. He concluded by moving the adoption of the report, the payment of the preference dividend, and the payment of the dividend and bonus recommended on the ordinary shares.

The VICE-CHAIRMAN (the Marquis of Tweeddale) having seconded the motion, it was carried unanimously.

The CHAIRMAN, in reply to Mr. Fisher, stated that the Company was now earning £400,000 a year net, and that the interest on the debenture stock which they were offering for public application was only £20,000. Having regard to the ease with which they could repair their cables, and to the fact that they had nearly £570,000 reserve fund, he repeated that the new debenture stock might be regarded with the utmost favour.

On the motion of Mr. JOHN NEWTON, a vote of thanks was passed to to the chairman and directors, and in reply,

The CHAIRMAN referred to the growing importance of submarine telegraphy, and expressed sympathy with Mr. Newton's remarks as to the amount of the dividend. If they had had open messages, as was expected at first, they would have been paying 60 per cent. instead of six per cent.; but the fact was that they had been beaten by the ingenuity of the merchants in the coding system.

The proceedings then terminated.

[We shall publish a *verbatim* report of this meeting in our next issue].

THE WEST COAST OF AMERICA TELEGRAPH COMPANY, LIMITED.

Report of the directors to be submitted to the sixth ordinary general meeting to be held on July 19th, 1883:—

The directors have to present to the shareholders the annexed accounts for the year ending the 31st December, 1882, showing the gross revenue to be £38,908 2s. 10d., against the sum of £32,356 15. 11d. for the previous year, and leaving a nett balance of profit, after paying debenture interest, of £7,667 11s. 1d.—a result, which, though not altogether satisfactory, is yet far from unpromising, regard being still had to the continuance of active hostilities on the West Coast, and to the utter paralysation of trade at Lima and elsewhere in Peru. Since the 31st December last, the date up to which the balance-sheet is made out, the Board are, however, pleased to state, a considerable improvement has taken place in the position and prospects of the Company. The mortgage upon the Company's steamer, and all the other liabilities and arrears of the Company, set down at £20,465 8s. 5d. in the Company's balance-sheet for the year 1881, have been discharged and extinguished, and the shareholders may now be congratulated on the Company being at length a dividend-earning concern. Without counting upon any increase of business which may be reasonably looked for from the conclusion of peace, and the improved condition of affairs on the West Coast, the gross average earnings for the past six months point to an aggregate income for the current year of more than £50,000—a sum sufficient, as will be seen on reference to the figures in the balance-sheet, not only to meet all the current engagements of the Company, but to form an adequate reserve, and also to pay a dividend on the ordinary shares. Instead of this income decreasing there seems to be every prospect of its increasing; whilst the Company's expenditure will, it is hoped, show at the end of the year a diminution rather than an increase. In view of the improving position and prospects of the Company, and also in view of the meetings of the Company being held only once a year, it is intended to submit a resolution, and take power, which can only be given by a general meeting, to declare interim dividends—subject to the formation of an adequate reserve—out of such profits as may be from time to time justly available. The claim of this Company upon the Chilian Government is still unsettled, but the Board have unabated confidence in ultimately obtaining from the Government a reasonable and honourable settlement. An important step has been gained in this direction by the institution in Chili of an International Commission, constituted to adjudicate upon claims arising out of the conflict between Chili and Peru. This tribunal, under the terms of its appointment, is happily bound to adjudicate upon all claims within a specified time. A satisfactory arrangement has been made by the Board with the Central and South American Telegraph Company, for the joint employment on the coast of this Company's repairing steamer. The new through route from England, and from the whole of Europe, viâ Galveston, extending to the entire coast of South America, is now attracting business by its expeditious and satisfactory working, the electrical condition and general efficiency of the cables leaving nothing to be desired. The members of the Board retiring by rotation are Mr. Thomas Fielden Campbell and Mr. W. E. M'Andrew, both of whom, being eligible, offer themselves for re-election. The auditor, Mr. J. Weise, of Messrs. Turquand, Youngs, and Co,, retires, and is eligible for re-election.

TRAFFIC RECEIPTS FOR JUNE, 1883.

COMPANIES.	June, 1883.	June, 1882.	Incrse.	Decrs.
Anglo-American Telegraph Company	—	—	—	—
Brazilian Submarine Company......................	—	—	—	—
Cuba Submarine Company............................	2,700	2,951	—	251
Direct Spanish Telegraph Company	1,552	1,963	—	411
Direct United States Cable Company	—	—	—	—
Eastern Telegraph Company	—	—	—	—
Eastern Extension Telegraph Company	34,307	31,122	3,185	—
Great Northern Telegraph Company	—	—	—	—
Submarine Telegraph Company	—	—	—	—
West Coast of America Telegraph Company	—	—	—	—
Western and Brazilian Telegraph Company...	—	—	—	—

COMPANIES' SHARE LIST.

TELEGRAPHS.

COMPANIES.	CLOSING PRICES JULY 11.		BUSINESS DONE WEEK ENDING JULY 11. Highest.	Lowest.
Anglo American	49,	60	49¾	49¼
Do. Preferred	81,	82	82	81¾
Do. Deferred	18,	19	18½	18¼
Brazil Submarine	11¾,	12	11 15-16	11¾
Cuba	10½,	11	10¾	10¾
Do. Preference	17½,	18½	—	—
Direct Spanish	5¼,	5¾	—	—
Do. Preference	15½,	16	15½	15½
Direct United States Cable	12½,	12¾	12¾	12½
Eastern Telegraph	10¾,	11½	11	10 13-16
Do. 6 per Cent. Preference	13,	13½	13½	13
Do. 5 per Cent. Debentures, 1899...	104,	107	—	—
Eastern Extension	11½,	11¾	11¾	11⅝
German Union	9½,	10½	—	—
Globe Telegraph and Trust Company.	7¼,	7½	7½	7 5-16
Do. Preference	12¾,	13¼	13½	12 11-16
Great Northern	12⅝,	12¾	12¾	12 11-16
Indo-European	31½,	32½	32½	32½
Mediterranean Extension	1½,	2	—	—
Do. Preference	5½,	6½	—	—
Reuter's	9½,	10	—	—
Submarine	247,	252	—	—
West India and Panama	1,	1½	—	—
Do. 1st Preference	6½,	7	6 9-16	6 9-16
Western Brazilian	6,	6½	6 1-16	6
West. Union 7 per Cent. 1st Mortgage	122,	124	—	—
Do. 6 per Cent. Sterling Bonds.....	103,	106	—	—

TELEPHONES.

Consol. Telephone and Maintenance...	⅜,	⅝	—	—
Oriental	⅜,	⅝	½	½
United Telephone	9½,	10	10½	9½

ELECTRIC LIGHT.

Anglo-American Brush Lgt. (£7 paid).	3½,	4	3 15-16	3¾
Do. (fully paid)	6½,	7½	6¾	6¾
Hammond Light	3,	3½	3⅜	3½
Swan	2½,	2¾	2 5-16	2½
Maxim-Weston	⅛,	¼	3-16	3-13

MISCELLANEOUS.

Telegraph Construction	33½,	34½	34¾	34½
India Rubber, Gutta Percha, and Telegraph Works	30,	31	—	—

TURKISH PATENTS.

NOTICE TO PATENT AGENTS AND INVENTORS.

The undersigned having established a special agency in Constantinople, are prepared to SECURE PATENTS in TURKEY for all inventions not yet in use in that country for £35, including drawings of average amount.

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PRACTICAL ELECTRIC LIGHTING. By A. BROMLEY HOLMES, Assoc. M. Inst. C.E., containing Explanations of the Principles on which Electric Lighting Apparatus is Constructed. Descriptions of machines, lamps, secondary batteries, &c. Particulars of prime cost and cost of maintenance. Practical directions for working the light, &c.

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NOTES.

Telegrams for South Africa.—The cable between Zanzibar and Mozambique is repaired.

Telegrams for China.—Telegraphic communication has been opened with Canton and Foochow.

Society of Arts.—The *conversazione* of this society is to be held at the Fisheries Exhibition on Wednesday next, July 25th.

South Africa.—The cable between Mozambique and Zanzibar is now repaired, and telegraphic communication with South Africa restored.

The Metropolitan Board of Works.—We understand that the petitions of the Board against the electric light orders have been withdrawn.

The Provisional Orders.—The Board of Works for the Westminster district have resolved to oppose electric light schemes affecting their district.

Use of Primary Batteries.—Messrs. Laing, Wharton, and Co. have temporarily lighted a bazaar at Lewisham with Swan 10 candle-power lamps, obtaining the current from Emmens's primary battery.

Prof. Forbes's Accumulator.—The Electrical Carbon, Storage, &c., Company of Scotland are issuing price lists for this battery. They give the E.M.F. at 2·5 volts, as against 2·25 volts of most other batteries. We fancy 2·25 volts is a rather high E.M.F., except in the initial stage of discharge.

The ss. "Gabo."—In consequence of the great satisfaction given by the electric light on the ss. "Berwick," the Electric Carbon Storage and Apparatus Manufactory Company, of Scotland, have received instructions to light up the ss. "Gabo," for Melbourne. One hundred incandescent lamps and two arc lamps will be used in this installation, Higgs's self-regulating dynamo machine being again employed.

The India Rubber, Gutta Percha, and Telegraph Works Company.—The half-yearly general meeting of this company will be held at the Cannon-street Hotel on Tuesday, the 24th instant, at 12 o'clock noon, for the purpose of obtaining the sanction of the shareholders to the payment of an interim dividend. The business of the company for the past half year has been satisfactory, and the directors will, at the meeting, recommend the distribution of an interim dividend of 5 per cent., or 10s. per share, free of income-tax.

Thunderstorms on the Continent.—On Friday evening last week a thunderstorm which burst over Geneva traversed the Jura, and the lightning set on fire the schoolhouse of Villers, in French territory. The children, forty-five in number, were half suffocated, and rendered so helpless that the master had to carry them out one by one. The last was rescued only a few minutes before the building was enveloped in flames.—A similar tragedy is reported from the village of Sotmar, near Brunswick. During a thunderstorm a mother and her four children, to whom she was reading, were killed by a single flash of lightning. Two other children who were close by were uninjured.—A severe thunderstorm, accompanied by waterspouts and hail, occurred in Silesia on Monday last, and caused serious damage. A paper manufactory at Eylau was struck by lightning and burnt down.

Electric Lighting at Walham Green.—The Butchers' annual fête, held on Tuesday, July 17th, at the Almshouses, Walham Green, was lighted by five Crompton arc lamps of 4,000 candle-power each, supplied with current by two Bürgin machines driven by a portable steam engine. Messrs. R. E. Crompton and Co. have lighted this fête for the last four years very successfully, but until this year fewer lights were used, and the large marquee in which the ball is held was lighted with candles. The committee, however, being so well pleased with the former lighting of the grounds, determined to use electricity inside the ball tent, and therefore instructed the contractors, through their indefatigable chairman, Mr. Calcutt, to fix two arc lamps in place of the candelebras usually containing a large number of candles. The effect of the lighting both inside and out was very fine, and gave great satisfaction.

Sixpenny Telegrams.—In reference to sixpenny telegrams, says the *Echo*, it may be noted that at the last preliminary examination held by the Civil Service Commissioners for male telegraph learners, nearly thirteen hundred candidates presented themselves. They will all be wanted if the sixpenny rate is adopted, but unfortunately it takes many months to train an operator, and a very large percentage of candidates fail when the test of practical work is tried. Any fifth standard Board School boy can easily pass the preliminary examination; but the actual work of the telegraph requires special faculties, and those may be found highly developed in lads who are not otherwise so bright as their competitors. At any rate, the telegraph service offers quite as profitable a field as the majority of trades, and is worth the attention of parents who, having sons and daughters, are at a loss for an occupation for them.

The Edison Electric Light.—The Criterion Theatre, Piccadilly, is to be lighted throughout with about 600 Edison incandescent lamps. The generating plant will comprise two Armington and Sims horizontal high-speed engines, having 13in. cylinder by 13in. stroke, running at 275 revolutions per minute, and driving on to countershafting from which will be run four Edison *l* dynamos each capable of sustaining 150 sixteen-candle lamps. Each engine will be capable of indicating eighty-four horse-power at 70lb. pressure, and either engine will thus be able to take the whole load in the event of accident or repairs to the other. The wiring will be arranged on eight circuits, each under independent control, by means of a specially designed regulator capable of lowering or raising the brilliancy of the lamps from normal candle-power to *nil*. The contract for the work, which will be carried out by the Edison Electric Light Company, stipulates for the completion of the installation by the beginning of September.

Sheepish.—The intelligence of the press on technical matters in this country is on a par with that of a baby on soft soap. As soon as an exhibition opens the various papers commence to "report," but the peculiarity remains that the same errors run through scores of reports. One such error in matters electrical is now going the round of the press. We could, if we chose, point out the paper in which the error was made, but it would be impossible to point out the score or so of papers who have faithfully copied the error. Is the Leeds Forge Company's exhibit at the Metal Trades Exhibition lighted by a "storage," or by a primary battery? The papers say it is from a storage battery, and is as successful as it is pleasing in effect, and the result shows the progress made towards independent house lighting from storage batteries. We shall be glad to hear of the firm that claims this storage battery. The lighting may be successful, may be pleasing, may, indeed, be perfect, but whose is the storage battery? We are prepared to maintain, and we think we can prove, that not 5 per cent. of those who report exhibitions ever see the exhibits.

Stalybridge.—At a late meeting of the Stalybridge Town Council, in moving the confirmation of the minutes of

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the Finance Committee, reference was made to an item of £10 odd which appeared in the accounts as the expenses of opposing an Electric Lighting Bill in Parliament. It was thought unfair that any company could put them to the expense of opposing their Bills. In this instance the company brought forward a Bill which was illegal, and after a time it was withdrawn. This year the company had again applied for powers. It is something of a scandal that two or three electric lighting companies can put corporations to expense, and that, when the corporation opposed the Bills and won the case, no costs could be obtained. Every corporation in England is interested in the matter, for all were liable to be put to expenses of this kind. It was a hardship upon the ratepayers that adventurers could form companies, come and frighten corporations, and make them pay into the bargain. It was believed that in many instances these Bills were got up by the score. Printed copies were sent round to corporations, who were put to the expense of opposing. Then, when powers were got, they were simply sold for pounds, shillings, and pence, and companies were making dividends by selling privileges which they got from Parliament for nothing, while corporations were bearing the expense of opposing.

The Telegraph in Journalism.—In an address on "Journalism," delivered by Mr. Charles Emory Smith, at Lafayette College a few days ago, the speaker referred to the part played by the telegraph in the development of modern journalism, and said: "A number of journals now have their own special wires from leading points. The time will soon come when, apart from their ordinary news-gatherers, they will keep the ablest men they can find constantly at the capitals to deal critically with the operations and the legislation of the hour; when the editorial comments will be written on the scene, with all the colour and life and intelligence of actual presence; when they will be put upon the wires as freely as the general news—nay, further, the time is near at hand when the keenest and most experienced observer, waiting till the last moment for the freshest phases in the kaleidoscopic changes, will stand at the telephone in Washington and talk his clear, well-digested comment; when it will be simultaneously received in the newspaper office in Philadelphia, instantly converted by the type-writer into printed copy, and immediately passed on to the composing room. In short, when the carefully gathered information of the acutest journalist spoken in Washington at one o'clock in the morning over the wire will be all ready at two o'clock in Philadelphia to be-rattled off the printing press at the rate of fifty thousand an hour."

Expected Strike of Telegraph Operators in America.—According to a telegram received by the *Daily News* from its New York correspondent on Tuesday, a committee of telegraphers, professing to represent fifteen thousand operators, formally presented the demands of the association to the Western Union Company, and requested a general increase of 15 per cent. in the salaries, and a reduction of one hour in the day's work. No time for the reply was stipulated for, and no threats were made. A general strike within a few days is imminent. According to the *Standard* of same date, the strike of telegraph operators is extending and threatens to stop the entire service in the States. The Direct Atlantic Cable and the French Cable Companies are not affected by this suspension of work. The object of the clerks is to obtain better hours and equal pay for the same amount of work, whether it is done by men or by women. The men fear lest their rate of pay should be reduced to the same scale as the women's. The organisation of the operators is strong, but the companies declare that they are prepared to meet it. The Operators' Committee have formally requested an advance in wages of fifteen per cent., and a reduction of the hours of work from nine to eight. No answer has yet been given. Telegraphing on Tuesday the *Standard's* correspondent says "The telegraph operators on strike are confident of success; the company is determined to defeat them." On Wednesday the same correspondent telegraphs that the Western Union Company, without directly answering the operators' delegates, has appointed a committee to consider the complaints of the servants. This is regarded as an evasive step, and a strike is still possible.

Legal.—In the Queen's Bench Division of the High Court, on Thursday, Mr. Justice Lopes and Mr. Justice Williams, sitting in banco, had before them the case of "The Central News *v.* the Eastern Telegraph Company and the Exchange Telegraph Company," an action brought for alleged divulging of telegrams sent from the plaintiffs' agent at Kassassin by the Eastern Company's wires during the war in Egypt. The case did not come before their lordships on its merits, but merely on the question of allowing the plaintiffs' agent, Mr. Burleigh, the plaintiff's special correspondent at Kassassin, to be present during the examination of witnesses by commission, preparatory to proceeding with the action—these being some telegraph clerks now home temporarily from foreign stations.—Mr. Finlay, Q.C., with whom was Mr. Moulton, as counsel for the defendants, remarked, however, that these preliminary proceedings were in the nature of "a full-dress rehearsal," being an inquisition with the object of making out a case against his clients. The defendants objected to the presence of Mr. Burleigh during the examination of these witnesses, on the ground that he was a director and shareholder of the plaintiffs' company, and a principal witness for the plaintiffs in the cause.—Mr. A. M. Sullivan, who appeared as counsel for the plaintiffs, submitted that the objections of the defendants were not substantial, and stated that the examiner himself had expressed the opinion that Mr. Burleigh ought to be present during the examination, although he had referred the matter to the Court in order to avoid any dispute on the point hereafter. Having heard counsel, the Court decided that Mr. Burleigh ought to be present.

A Compromise.—A foreign paper devoted to gas-lighting interests announces an invention which promises to bring the two rivals, gas and electricity, into close partnership. Through an ordinary gas flame a curved metallic rod is passed, the said rod consisting apparently of platinum, though this is not very clearly stated. A slight current of electricity, such as would be supplied by one or two small elements, passed through this rod will be found, it is said, immensely to increase the illuminating power of the gas flame. A light four or five times as great as that of the unassisted flame, and at a cost of one-third, is the result announced, though as to all such calculations it really seems to be of little use to take any notice of them when inventors and their friends trot out their little bantlings; but if it should prove to be the fact —and the statement is one which any electrician may put to immediate test, and would hardly, therefore, have been put forward without some degree of truth—that a slight current passed through a platinum wire will affect a gas flame as asserted, it may have very important results in connection with domestic arrangements for lighting and heating. The relative proportion of luminous and heat rays is completely altered, it is affirmed, and the arrangement is capable of furnishing "all gradations, from the brilliant flame to the most calorific radiations." It is very well known that a gas for heating purposes only could be supplied to housekeepers at a

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much lower rate than for lighting, and, if this invention should be capable of acting as it professes, it seems very possible that a gas supply of the cheaper description, adapted for heating alone, may by the co-operation of the electric current be converted instantly into an illuminating agent. In the interests of consumers, therefore, it is to be hoped that this reported invention is genuine.—*Globe*.

INTERNATIONAL ELECTRICAL EXHIBITION, VIENNA.—According to official information the following states, besides those previously mentioned, will be represented at this exhibition by delegates:—Belgium will send the engineer, Mr. Evrard, who has been likewise entrusted with the organisation of the official Belgium section, together with Messrs. Rau and H. Witmeur. Roumania will officially send Professor Bacaloglu and Captain Michel Boteanu for studying the exhibition. From Russia will come the general telegraph instructor, Mr. Pissarewsky and Mr. Tiedemann, sent by the general direction of the Imperial Russian Telegraphs as delegates. Mr. Ph. Welitschko, president of the commission, also attends for Russia. The commission has been formed by command of the Russian Emperor for the organisation of a Russian section. The Imperial Russian Polytechnical Society will send as delegates Messrs. Oreste Darislowitch Chivolson, Doctor of Physics, and Colonel Wead Takowlewitch Florensoff, Professor of Chemistry at the Cavalry School of the Emperor Nicholas; as chief commissionary of the Russian section, Mr. T. L. Crestin, engineer at the Public Cartridge Factory; as commissaries, the electrician, Mr. A. N. Ladriguine, and the Professsor of Physics, Mr. Jacques T. Kowalsky, and finally as deputy commissaries, Colonel Michel A. Saline, Professor of Mathematics in the Imperial Corps of Porges; Mr. Michel M. Dochenoff, mine engineer; and Mr. Serge Nikolajiwitch Stignanoff, electrician and editor of the Russian journal, *The Electricity*. From Turkey the general post and telegraph director, Mr. Izzet Effendi, who has been ordered by the Turkish Government to organise the Turkish section, has nominated as delegates for the exhibition the president of the Technical Bureaus, Mr. Emile Effendi Lacoine and his colleague Mr. Raif Effendi.

MR. EDISON AND ELECTRIC RAILWAYS.—Commenting on the reported interview with the great inventor which we mentioned in our last, the *Echo* remarks "Mr. Edison has been 'interviewed' recently on the subject of electric railways, and as he probably had no objection to undergo the operation, there is possibly some substratum of fact in the reports published; but it will be news to many to learn that he is building an electric locomotive of 375 indicated horse-power and six-foot driving wheels, which is to be used on the Underground Railway in London, 'where smoke and vapours are very offensive.' This engine is to haul from eight to ten passenger coaches at a high rate of speed, from forty to fifty miles an hour; and as Mr. Edison promises to make it perform what he has undertaken, it is to be hoped that the pioneer engine will soon be on its road. Mr. Edison, however, does not think that electricity will be generally adopted for heavy trains or over long distances, but he and his partner, Field, have many applications for the use of their patents—the motor of the future being, in Mr. Edison's opinion, of one the designs patented by Mr. Field. Although steam will eventually be superseded by electricity as a motive power, in Mr. Edison's opinion, he does not think the change will be effected just yet; but, as a climax, he expressed another belief, that, sooner or later, means will be found to obtain electricity from the earth without any machinery whatever. Happy days those for everybody; but we expect the electric locomotive on the Underground will arrive long before electricity to work it is obtained from the earth, except in the shape of that other form of energy commonly called coal. For the sake of Mr. Edison's reputation, it is to be hoped that the interviewer has misunderstood him, for the idea of drawing electricity from the earth has neither the merit of novelty nor the probability of dethroning King Coal."

THE TELEGRAPH A NUISANCE.—To old-fashioned people—and most people are old-fashioned nowadays who have passed Thackeray's critical age of forty—the telegraph is an unmitigated nuisance. To begin with, it is enormously expensive; it has added to every firm's expenditure a constant drain of 2,000 dols. to 10,000 dols. a year, with no corresponding increase of profits or commissions. It wastes time to an incredible extent; the cost of every word has induced the manufacture of the most elaborate codes, in which the most impossible words convey deeply involved sentences. As all languages are used in the compilation of these codes, and no telegraph line can provide all its assistants with an unlimited knowledge of languages, mistakes are frequent, and the unfortunate recipient of a message wastes his time first in endeavouring to solve the riddle presented by a mistake of, say, two letters in an Italian pluperfect, and then in asking for a repetition of the unsolvable problem. It used to be one of the alleviations of exile that mails came in with the news with reasonable regularity, and one knew when one would hear from home, and when one would have to write. Whatever one's personal news, there was always a batch of newspapers to read, and for these, at least, one could greet with pleasure the sound of the mail guns. But the telegraph has spoilt all this; there is no longer sequence or continuity in the news we get. What in the old days would have been welcome as actual news in the *China Express* now comes in little scraps by Reuter or Indian papers, or from San Francisco journals, or from Australian exchanges, and sometimes from all four, until all our interest is destroyed by the scrappy and inconsequent form in which it reaches us. There was a time when we could attentively follow the progress of the training for the Oxford and Cambridge, or the betting for the Derby, or of some great trial; but now we get the result before we get the processes, and our intellect is as little satisfied as our stomach would be if we were given a teaspoonful of Liebeg instead of a well-served dinner. It was Artemus Ward who said that it would be money in his pocket if Columbus had never discovered America. Certainly life would be far better worth living if scientists had avoided the discovery of the electric telegraph. —*Celestial Empire, Shanghai.*

MAGNETIC STATION AT ST. MAUR OBSERVATORY.—This station was built last summer by Mr. Mascart, the director of the Paris Meteorological Station, and consists of a pavilion 23ft. long by 16½ft. wide, the short side being in the geographical meridian; this contains two vaulted caves, each ventilated on three sides by air-holes, which in the eastern cave are darkened, without, however, excluding the necessary ventilation. The instruments used in each cave for determining the magnetic direction and intensity are three, viz., the declinometer, the bifilar, and the magnetic balance, all mounted on masonry pillars about 6½ft. apart, those in the western cave being read directly by telescopes, while the indications of those in the eastern cave are automatically recorded by photography. To obtain a continuous record of the latter, Mr. Mascart has invented a magnetometer, which, while in no respect less accurate than the Kew one, offers the following advantages:—(1) Is considerably less costly; (2) requires a smaller magnetic cave; (3) em-

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ploys only one lighthouse for the three instruments; (4) registers all the elements on the same sheet of paper. It consists of a case divided in two throughout by a wooden partition; the back contains the clockworks, while the front forms a dark chamber which contains the photographic slide moving in a grooved frame, which, by means of a rack and toothed wheel, driven by the clock, descends behind a window in the case once in every twenty-four hours. The clock pendulum oscillates in a plane parallel to the magnetic meridian. The light is supplied by a small gazogene lamp, which, well regulated, will burn steadily for thirty-six hours; by charging it at a fixed hour daily, a constant illumination is secured. The focus of the lamp is centred in a lantern fixed to the clock case, and fitted on each of its three free sides with a metal frame carrying a field lens and a vertical slit, which can be narrowed at will. One of these slits sends a ray to the declinometer, a second sends to the bifilar, and a third to the balance; and these are so arranged that the luminous images, after reflection on the fixed and movable mirrors of each instrument, are returned clearly upon the sensitised paper, one-third of the breadth of this paper being reserved for the indications of each instrument. Six traces are thus obtained upon the paper, three being the fiducial lines of each of the elements, and three the curves of their variations. The deviation of a curve to the right of the fiducial line for each element is proportional to the angle between the mirrors. The hour is also recorded upon the paper, the clock movement being arranged so that the grooved frame falls exactly 1 centimetre (0·4in.) an hour, the total curve-length being thus 24 centimetres (9½in.). The paper is pressed in the slide between two sheets of glass, one of which (the one on which the sensitised side rests) is transparent, and bears twenty-five horizontal studs, each 0·4in. apart; these studs appear in turn before the window in front of the photographic slide, and, by intercepting the light, cause breaks in the lines formed on the paper. The exact time at which each sheet is inserted is written upon it afterwards, as also the date; but all other inscriptions are made photographically. The slide is remounted, and the lamps renewed daily at mid-day.

Thunderstorms.—London and its neighbourhood were visited by severe thunderstorms on Saturday and Sunday last. When the storm on Saturday was at its height, about 4:15, a flash of lightning passed through the house No. 47, Walden-street, Mile-end Old Town. It entered the window of the first floor back room, where three children, viz., Mary FitzHenry, aged nine; Joseph, aged seven; and Kate, aged five years, were sitting at play. Joseph was thrown to the floor and rendered insensible, whilst the clothing of the eldest girl was set on fire, causing her to be severely burnt about the arms, legs, and body. The hair and clothing of the third child were also burnt, but she sustained no serious injury. The lightning then passed through the bed, setting that on fire, and through the floor into the room below, where it scattered the things about in an extraordinary manner. Shortly after the above occurrences the house No. 45, in the same street, was struck by the electric fluid, and the chimney-stack and roof injured.—The storms were severely felt in West Middlesex, where the lightning was intensely vivid and the flashes unusually frequent, but no fatalities have as yet been reported.—On Saturday, during the heavy thunderstorm, a man named Edwards, in the employ of Mr. Reynolds, landlord of the Golden Lion Hotel, at Romford, was blinded. The poor fellow was engaged in the yard of the Golden Lion with a pitchfork while the storm was at its height at about one o'clock, when a flash of lightning caught the steel end of the fork, the result being that the electric fluid was transmitted to Edwards's face. Edwards, who is a married man with four or five children, was taken to the surgery of Dr. Wright, and this gentleman, after examining him, found that the poor fellow's sight had been taken away.—During the thunderstorm on Saturday afternoon the electric current entered the Post Office at Wallingford, and so injured the telegraphic apparatus that no messages can be received or despatched until the instrument is repaired.—At Llanarth, near Raglan, in Monmouthshire, a man was killed while driving a mowing machine.—The astronomical observatory at Mitchel Troy Rectory was much damaged.—At Coleford two hay ricks were set on fire, and numerous trees have been shattered in the district, communication being much interrupted. —At eleven o'clock on Saturday morning a thunderstorm of unusual severity was experienced at Kingston-on-Thames. While the storm was at its height the lightning struck the flagstaff of Kingston Church, splitting it into pieces. Some of the splinters of wood were carried a considerable distance. One of the bolts securing the staff was carried away.—A heavy thunderstorm passed over Brighton on Sunday afternoon, and St. Matthew's Church was struck by lightning, considerable damage being done. The church, which has just been built in the east part of the town at a cost of £10,000, was only opened on Friday. The lightning struck the cross on the east side over the chancel, taking it completely off, and carrying with it a portion of the coping. The pole was splintered into fragments and fell into the yard below, the contractor's watchman having a narrow escape. The Sunday School children were in an iron building on the north side of the church at the time, and when the crash came rushed for the door, but through the presence of mind of the superintendent a panic was fortunately prevented.

Defence against Lightning.—Colonel Parnell, of the Royal Engineers, published recently in the *Newcastle Daily Chronicle* the following hints:—*Out of Doors:* (1). Persons obliged to work out of doors during the summer and autumn should carry *as little metal of any kind* about them as possible. [A rule of the most intense importance. Remember that nails in boots, buttons of trousers, money in pockets, metal on tobacco pipes, all are most attractive, besides such more palpable articles as rings, watches, studs, &c.] (2). If caught in a thunderstorm, endeavour to get inside the nearest *brick* or *stone* building before the thundercloud arrives over where you are. (3). If this be impossible on account of the absence of such buildings from your vicinity, and if you are already quite in the open and away from trees, or other shelter, *on no account move;* but let yourself get drenched, and if you can, lie down on your face till the thundercloud be past. [The object is to diminish your height above the surface of the ground as much as possible.] (4). *Avoid shelter like poison.* If you can get right inside a brick or stone house, do so; but do not stand just inside the door; and by no means go into *outhouses*, such as barns, stables, sheds, &c. But especially avoid mere temporary shelter, such as that given by trees, walls, cliffs, quarries, hedges, banks, hayricks, or other outdoor objects. (5). Wooden buildings of all kinds, and especially *wooden sheds*, are dangerous; but a low building wholly of metal (say a temporary church of corrugated iron) is not generally a source of danger. (6). If you have time to choose your position in the open, when the thunderstorm approaches, choose *low* ground rather than high, *dry* ground rather than wet, *rocky*, *stony*, or *paved* ground rather than grass, earth, or ordinary macadamised roads, and *leeward* sites rather than windward ones. [The choice of ground is of very great importance. It is almost certain that every lightning stroke *springs upwards*

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from the earth and downward from the thundercloud simultaneously; and the chances of a thunderbolt occurring *at all* at a place are greatly influenced by the nature of the surface of the ground. (7). If labourers in a field have to leave their work, they should on no account take with them their hoes, scythes, hayforks, or other metal implements. *Indoors*: (1). Keep well away from the kitchen fireplace. If you can, go into some room or passage where there is no fireplace. [Chimneys are great sources of danger.] (2). Keep away from all walls, but particularly from the *outer* ones. (3). Especially avoid the neighbourhood of any *metals* on or near the walls, such, *e.g.*, as gas pipes, water pipes, bell wires, window bars and fastenings, sash weights, ventilators, door fastenings, cisterns, sinks, looking-glasses (on account of the mercury), pianos, gilt ornaments and picture frames, tie rods, cranes, rain water pipes, balconies. (4). Close all windows and doors. (5.) Keep your kitchen chimney clean. [Soot is very attractive.] (6). So far as lies in your power do not have any *metal* on the outside of your house especially in elevated places such as chimney pots and eaves gutters. [Elevated metal is usually the cause of buildings being struck.] (7). A piece of paving close round the walls tends to prevent a building being struck. (8). Keeping the ground around them dry and well drained has a similar tendency. (9.) Fixing a few sharp-pointed spikes somewhere on the ironwork of the kitchen grate, and at the same time connecting the bottom of this latter to the ground by means of a bit of old iron passing through the hearthstone and about six inches into the soil, tends to *tap* the ground of its dangerous electricity, and hence to avert lightning strokes. [These strokes are merely *explosions* of pent-up electricity.] In conclusion, it may perhaps interest your readers to know that the ravages of thunderbolts occur in all countries, chiefly among the *poor rural classes*. It appears from official records that the number of persons killed by lightning in the Russian Empire (exclusive of Poland and Finland) during the five years from 1870 to 1874 was 2,270, of whom 2,161 were dwellers in the country; also that, during this period 4,192 fires were occasioned by lightning in the same area, of which 4,099 occurred in the country. My own impression on the subject of the defence of the United Kingdom generally from these dreadful thunderbolts is that Government should for a few years scientifically examine and minutely record every fatal or destructive lightning stroke that may happen in Great Britain and Ireland, and should make some attempt to interpret the laws, meteorological, geographical, and physical, which Nature follows in these wonderful manifestations.

THE EASTERN TELEGRAPH COMPANY.—The Four per Cent. Debenture Stock now being issued by the Eastern Telegraph Company at £95 per £100 stock offers exceptional advantages to investors, not only when compared with the existing debentures of telegraph companies, which are of a temporary character, and liable to be paid off in a more or less limited period, but in comparison with the similar stocks of railway companies. The Eastern Telegraph Company possesses main trunk lines of cable which join India to England, and touch only at places owned or controlled by the English Government. The permanence of this great and important means of communication with the East is assured by the existence of several independent lines of cables belonging to the company. These are kept in so high a state of efficiency that interruption of communication is hardly more likely to occur on these lines than on the railway between London and Liverpool. But, even should a temporary interruption happen, communication can be infallibly repaired in a very short period, and the company, by its arrangements with other telegraph administrations, would lose hardly any revenue. In addition to the trunk cables to India the company owns a network of submarine telegraph lines joining all important points on the Mediterranean and Black Seas, and rendering communication between England and the various countries and places served by the company more rapid and secure than could possibly be effected by land wires operating over such great distances. The income of the company has always been large, and has latterly made steady progress, the following being the net income of the past five years, after paying all expenses, including the cost of repairs:—

Net income year ending	March 31,	1879	...... £269,037
Ditto	ditto	1880	 346,965
Ditto	ditto	1881	 367,522
Ditto	ditto	1882	 368,881
Ditto	ditto	1883	 400,776

During this period the capital of the company has only been increased by £345,000, the additions to capital in the two years since March, 1881, having been only £7,000. On the other hand, in the same period of five years, the reserve funds have been increased from £159,224 to £569,828, or by considerably more than the total additional issues of capital, while a large amount has in the period been paid for out of revenue on account of the purchase of a maintenance ship and the expenses of the steamers laying new cables. The present total annual charge in respect of debenture interest absorbs only about 11 per cent. of the net available income of the company, while it is common to see similar charges in English railway companies of first-class standing absorbing 20 per cent. and more of the net revenue. The mortgage debenture stock now being issued will be a first charge on the undertaking and revenue of the company, and the company's power of issue is strictly limited to one-third of its paid-up share capital, so that, were the whole of the borrowing powers immediately exercised, and were no increase or income to result from the additional capital outlay (which is, to say the least, improbable) the charge for the service of the Debenture Stock would absorb only £60,000 out of a net revenue of over £400,000, being at the rate of 15 per cent. of the net income, showing an unusually large margin to cover any possible loss of traffic, additional expenses, or other unforeseen contingency. The magnitude of the reserve fund provides a security which, it is believed, is unprecedented in any other class of business enterprise, the present amount being nearly £570,000 against a total present bonded debt of only £882,000. The price at which the Debenture Stock is now issued, viz., £95 per cent., gives a return to the investor of slightly more than 4 1-5 per cent.; the existing Preference Shares of the company, at present quotations, give a purchaser barely $4\frac{1}{2}$ per cent., and this latter security ranks necessarily after the whole of the authorised indebtedness of the company. The following table compares the return to an investor in the Eastern Telegraph Company's Debenture Stock with that obtainable by a purchase of railway debenture stocks according to the prices current on June 30th last:—

STOCK.	Price June 30.	Yield per ct.
Ln. and Nth. Wst. Rly. Four per Ct. Deb. St.	117 ...	3 7 6
Gt. West. Rly. Four per Cent. Deben. Stock	115 ...	3 7 6
Nth. East. Rly. Four per Ct. Deben. Stock	115 ...	3 7 6
Gt. East. Rly. Four per Cent. Deben. Stock	112 ...	3 10 0
L.C.D. Rly. Four per Cent. Debenture Stock	108 ...	3 15 0
Nth. Brith. Rly. Four per Ct. Deben. Stock	108 ...	3 15 0
East. Telgph. Com. Four per Cent. De. Stk.	95 ...	4 4 2

—*Money Market Review.*

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POTENTIAL, CURRENT, AND RESISTANCE.

BY JOHN T. SPRAGUE.

In Vols. II. and III. of *The Electrician* there was a prolonged discussion on the subject of Potential, in which several eminent electricians took part, and which, if it did not clear up the subject, made it very clear that there existed much difference of opinion about it. In papers by myself at a later period on the transmission of large currents, the constants of the electric current, and current force and energy, I endeavoured to work out some ideas of my own as to the nature of electromotive force, and the analogy between electric currents and those of water, but did not carry this out completely. Having had recent occasion to examine the subject again, with the result of further developing some points which appear to be of interest, I propose now to present them fully worked out, though in so doing I must of necessity again go over the matters contained in former papers. As force is the origin of action, conduction its channel, and current the result, that order of consideration might appear reasonable, but these divisions cannot be wholly maintained, and I do not propose to attempt it, but shall take the various subjects as they come convenient.

1. Current is most easily conceived because it deals with actual tangible facts in nature, while the others are matters of calculation. Current in electricity, as with water, means the rate of passage of unit quantity across any section of the conductor; its most definite evidence and measure is the chemical action produced by the passage of electricity through liquids. Unfortunately, the accepted unit of electric quantity, the coulomb, does not accord definitely with the natural unit

$$\frac{\text{Atomic weight}}{\text{Valency}} = \text{electric equivalent},$$

which would make one of hydrogen represent the unit of electric quantity, and, with the element of time, the unit of current; but though only a fractional value represents the relation, and it is not even settled whether the real value of the coulomb and ampere is ·00001022 or ·000010415 of a gramme, still this is the true physical representation of electric quantity, which corresponds to "mass" in mechanical calculations.

2. In the older works on electricity "quantity" currents and "intensity" currents were spoken of, and even now we occasionally meet with such an unmeaning phrase as the "tension" of a current. All such ideas, which give the impression of some difference of nature in currents, are misleading. Current, as such, has only one quality, its rate; a given current, that is one which will produce a certain deflection in a particular galvanometer, or will deposit a certain weight of metal from a solution, is exactly the same in its nature and properties whether it comes from a large or small cell, from a single cell, or from a thousand cells in series. But the same current may have different effects according to its *density*, that is according to its ratio to the sectional area of the conductor, or its quantity per unit of area. This influences the temperature generated in wires, and is of supreme importance in electrolysis, so that it is unfortunate that some writers have taken to using the already misapplied term "intensity of current" for this ratio.

3. Ohm's Laws.—These laws or formulæ are universally employed by electricians, but are not confined to electricity, as they express the common fundamental mechanical laws. The relations established by Ohm's laws between electromotive force, resistance, and the current and its work, are simply the well-known laws of mechanics or the relations between force, such as gravity, weight, and velocity; and the laws themselves are merely mathematical expressions. Invaluable in dealing with the modes of operation, they only delude us if we regard them as facts, and do not clearly trace out the reasons why they are valuable. Mr. Oliver Heaviside has made some remarks on this subject (pages 149 and 150), in which this matter seems to be curiously undervalued, when, after referring to the confusion in some minds as to electric resistance, he remarks that "R is just called so," and again, "if ideas are correct it is of secondary importance what language is used to express them." But that is just the point; a writer's idea may be correct, but when he has to use words which have already an entirely different meaning, it is by no means sure that his readers' ideas will be correct. It is in fact only quite lately, and in no degree consequent upon the teachings of the professional teachers of electricity and their formulæ, that people are beginning to understand that R, the electric *resistance*, is not resistance at all as commonly understood. When he suggests that the fact that this so-called resistance presents no more obstacle to a large current than to a small one (p. 199) is a powerful argument in favour of providential design, one is apt not only to smile at his suggestions of a soporific, but to doubt whether he has himself fully realised that the fact itself results merely from an arithmetical artifice explained in my earlier papers referred to, and which I shall recur to in due course.

Multitudes of students are misled by this misuse of the the word resistance, and eminent electricians and engineers have been equally deluded. Mr. Siemens said in a public lecture:—"My critics have, however, fallen into the error of overlooking the fact that half a unit resistance is the same for a circuit capable of working one lamp as it is for working 100 or 1,000 lamps. *Electricity is not conducted upon the conditions appertaining to a pipe conveying a ponderable fluid*, the resistance of which increases with the square of the velocity of flow." Sir W. Armstrong, in his address to the mechanical section of the British Association in 1881 says:—"In the case of a fluid current through a pipe the resistance to the flow increases as the square of the velocity, while in the case of an electric current the resistance through a given conductor is a constant proportion of the energy transmitted. So far, therefore, as resistance is concerned, electricity has a great advantage over water for the transmission of power." So we may see that by converting mathematical formulæ, which are nothing but mental tools (apparatus for mechanical thinking in some sense), into actual facts and theories, electricians have actually been led into great errors as to the nature of the electric constants.

In these quotations we have two distinct statements—1st, that in electricity a resistance is the same to all currents transmitted; 2nd, the sentence italicised, that currents of electricity and currents of water depend on different laws. Most electricians then, and many of them now, would endorse those statements. I dealt with them at the time in the pages of *The Electrician* and the *English Mechanic*, and will now show clearly what is really the thing that is alike for large and small currents, and also that *water in pipes and electricity in wires are conducted upon identical conditions.*

4. The fundamental expression of *Ohm's laws* is $\frac{E}{R} = C$, which means force (or more correctly "potential") divided by resistance defines the current, or rate of flow.

It follows that any two of the three elements, E, R, and C, being known, we can calculate the third thus, using the units of the B.A. system: the volt for E.M.F., the ohm for resistance R, and the ampere for current C.

Current.—$E \div R = C$. Force and resistance being known.

Electromotive Force.—$C \times R = E$. Current and resistance being known.

Resistance.—$E \div C = R$.

Energy $= C^2$, the square of current, in unit, or unaltered conductor, or $C^2 \times R$ as a general law.

5. The usual expression of the meaning of the formula is, *current* is *as the force* and *inversely as the resistance.* In order to fix the mind upon the ideas I wish to develop, I give this modified definition: *Current* is *as the E.M.F.* (which is *potential*), and *as the conducting capacity.* That which in the usual expression *is called resistance*, is simply the *reciprocal of the conducting capacity.* It has nothing to do with anything commonly known as resistance.

6. According to these relations, C varies as E, but energy, as work or heat, *which are the true resistance*, varies as E^2,

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that is as the square of either C the current, or E the E.M.F., in unit or any unaltered conductor, and it also varies as the so-called resistance; that is to say, it is inversely as the conducting capacity of circuits. This is precisely the ordinary law of mechanics, say in friction, where work absorbed is as the square of velocity, and directly as some other element, such as weight.

7. The very first point as to which a clear understanding is necessary is whether these symbols E, R, and C have any realities behind them. Do they represent facts, and if so, what facts? Or are they merely mathematical expressions, simple tools of thought? If the latter, we must carefully avoid the error of mistaking them for facts, lest, like the monster Frankenstein, they prove too much for their creators. It will be more convenient to examine this while studying Ohm's formula as a whole, than to treat each head singly.

8. *Electromotive Force.*—Is the E.M.F. which we symbolise by E *a force?* Let us see what idea we can form of it. A force tending to set electricity in motion; or, to use a better phrase, to set up that motion which we call electricity. Here it will be seen we have two considerations presented to us: an effect, the motion produced; a cause, the force producing the motion. Of these the first, the motion, is of necessity an actual fact, though we may hold different ideas as to what is the thing. But does the *cause*—the *force*—exist, that is to say, the special force? There are actual forces having real existence, such as the various attractions, of which we may take gravitation as the type; these are, so to speak, self-existent—we know not their causes. But there are other agencies which we call forces, yet which have no actual existence. They are really transformations of energy, and are forces only in the mathematical sense.

9. *Development of E.M.F.*—When we dissolve zinc in a battery this force makes its appearance. It is said by some to be due to the contact of the two dissimilar metals. But one thing is certain—this force can do no work unless it is maintained by an equivalent supply of energy, and, as a matter of fact easily proved, the degree of electromotive force produced is measurable in terms of the energy transformed in its generation, which is measurable by the heat set free in the chemical combination.

But if we expose the junctions of two different metals to heat, we find electromotive force set up in degrees depending (1) upon some inherent property of the metals, and (2) upon the difference of temperature produced, which means, in fact, the quantity of energy which can be thrown into the circuit.

Similar results are found when we examine the E.M.F. set up by dynamo machines. It bears a definite relation to the energy expended. We find also that though electromotive force is constantly acting upon the circuit, it has no accelerating action. We therefore conclude that it has no actual existence, but is due to conversion of energy, and that it must in some way be equivalent to the energy which it expresses.

The effect of the ideas about to be presented is to show that E.M.F. is no occult effect of *contact*, or of cutting lines of force, &c.; that these are but "conditions;" that E.M.F. (or potential) is always an expression for, a measure of the effort of energy (potential or kinetic) to take the kinetic form under any particular conditions.

10. *Any agency may be called a force* which is capable of setting up motion, or altering the conditions of motion in a mass of matter. Thus, if we take a ball of lead and let it fall, motion is imparted to it by gravitation. We may push the same ball of lead along a table, or by muscular energy hurl it to a distance. We may strike it, as a cricket ball is put in motion, by a percussive blow; or we may, by aid of a gun, set it in motion by means of compressed air, or by the explosion of gunpowder. In all these cases motion is produced, and we may call the agency in each case a "force."

11. *Mechanico-Motive Force.*—We may embody all these in one expression, and say they are due to a "mechanico-motive force," the intensity of which can be measured by its capacity to produce momentum. Of course the object of this term is to obtain an exact mechanical counterpart to the electric expression, but this term, or something like it, has actually been employed in mechanics. We have then to see whether this mechanical analogue is a force, or what is its true meaning.

12. *Static and Dynamic Force.*—There are two ways of treating and measuring a "force." (1) By the *pressure* it produces. This is a static action, and it measures a force as a *degree*, not as a quantity. A force so regarded is an abstract property or power; it has no relation to energy, because it does no work, though it has a relation to *potential energy*, as will be seen later. (2) By the motion it produces in matter, and this, again, has two aspects. 1. *Velocity*, which may be general or abstract, as in the case of the force of gravitation when expressed by the ordinary symbol g, meaning its capacity of generating a velocity of 32·2ft. per second. 2. *Momentum*, in which the force becomes concrete and *quantitative* by the introduction of unit mass of matter, and unit time. But this is no longer true *force*, it is an expression of *energy*—of the work a force can do under unit conditions. The *dyne* is such a force, or, more truly, a mathematical expression for a unit quantity of force, and it is the same value, in reality, as the *erg*, the unit of energy. They are simply expressions for the two aspects, *cause* and *effect*, force and work, which of necessity are equal. This will, of course, be objected to by the mathematical minded; but this is a case where truly, "if the ideas are correct, it is of secondary importance what language is used to express them." The idea is an inevitable consequence of the conservation of energy. *Force expended and work done must be equal*, and the purpose of my statement as to their units, the dyne and erg, is just to impress that fact. The usual plan of regarding them as belonging to distinct orders is directed to another purpose —their practical application.

13. *Gravitation* as a natural force therefore produces (1) a static pressure (2) a velocity (say 32 feet per second) (3) a momentum in a mass (say 16 feet lbs. per second). It also produces *acceleration*, that is to say, acting continuously its effect is accumulative. This property would be important in a treatise on mechanics, but does not necessarily enter into the electric treatment of force; its effects are included in the actual velocity and momentum generated. But it may be well to point out that the ordinary conception of gravitation, as due to the attraction of the earth for movable bodies, is misleading, because it leaves out of sight the part played by the second body itself. The effect of this is that while we can express a spring or steam force as a pressure of so many pounds per square inch, we cannot so express gravitation *per se*. We shall deal with such a pressure presently as "head of water," but this is a compound expression. Besides the attraction of the earth, it includes that of the water itself, that is, its own weight (or more properly mass). Of course it is perfectly known that this attraction is really that of the two masses, earth and body; it is only the common way of thinking that I refer to, which reacts even upon science. In our utter ignorance of the real cause of gravitation, we fix our ideas upon the mere masses of matter, and satisfy ourselves with the statement that it is $\frac{M \times M^1}{D^2}$, and in that formula we bury away the agency itself, the most perfect representation we can find in nature of an omnipresent consciousness.

14. We wind up a spring, and we know we have stored our work in it. We wind up a weight, and we know we have stored our work in it. We speak of "potential energy" in both cases, but in how different a matter do we think of the two agencies of storage. One seems real and the other mythical; the one we call energy of *stress*, molecular strain; the other we call energy of *position*. But let us conceive a powerful spiral spring attached to a rope passing over a pulley, and thence to a winch by which the spring can be strained, or wound up. We have here a tangible agent to deal with. We see the strained spring, and we know that the spring, by virtue of that strain, will return us our energy by doing work equivalent to that employed in generating the *molecular stress*. But we replace the spring by a mere weight which we wind up, and then we talk of energy of position. It should be clearly realised that

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the two conditions are identical; in winding up the weight we have in some way, wholly unknown to us, put *a stress upon the earth* and stored energy just as certainly as in the spring. We do not know how, but in some way the force of gravitation is as surely an expression of energy stored up in matter as is the attraction exerted between two charged electric surfaces across the strained dielectric, which is expressed by the same formula, $\frac{Q \times Q^1}{d^2}$, and by the equivalent magnetic law, all these so-called quantities being, in fact, simply measures of the stresses or attractions exerted by forces.

HONOUR TO WHOM HONOUR IS DUE!

EDWARD DAVY AND THE ELECTRIC TELEGRAPH, 1836 TO 1839.

BY J. J. FAHIE, MEMB. SOC. TEL.-ENGS. AND ELECS.

(CONCLUDED FROM PAGE 212).

Mr. Davy's correspondence, which was broken off in our last impression, proceeds as follows :—

June 16, 1838.

My Dear Father: I have only time to say that I received from Messrs. Gibbs £130, and Mr. Carpmael informs me that the patent will be sealed early in next week. I must write you again to explain what I purpose doing as soon as that is accomplished, viz, to send circulars immediately to all the Boards of Directors of Railway Companies, and to give one, or more, public lectures on the subject, inviting as many influential people as possible to attend. It must now be pushed forward with all our might and main, and I hope it will not be long before it does some good.

You will soon hear from me again, and believe me,

My dear Father,

Your ever affectionate Son,

E. DAVY.

June 23, 1838.

My Dear Father: I think that I ought to give you notice from time to time of my moves with the telegraph, in order that, in case of any sudden accident to me, and the concern being in a promising state, my successors might know better where to take it up, and what I had been doing.

The patent has not yet passed the seal. I expect that it will about Wednesday, or Thursday next.

I have been endeavouring to make connections with some business men, to assist me in making negotiations with the railway companies, or in getting up a general telegraph company.* The principle on which I endeavour to engage their services is that of percentage on whatever money I may obtain for licenses under my patent, through *their particular influence, or interference.* The amount I have fixed upon is 10 per cent., which will perhaps be liable to deviations in some cases. The present difficulty is in getting the thing *started.* When known practically and appreciated, it may be that the companies will come to me, instead of my having to seek after them.

The best business man I have at present retained is Mr. P—— * * * * I requested him to apply first to the Birmingham Railway Company, and the subject has been brought before the directors. The only answer obtained is that, if ever the directors should deem it necessary to adopt any electrical telegraph, they will make the most minute and careful examination into the comparative merits and advantages of each plan before deciding on either. I saw Mr. Creed, secretary to, and original getter-up of, the Birmingham Railway Company, who told me only that he would be happy to receive any memorial from me on the subject of my invention in order to lay it before the directors. Mr. P. is to introduce me to their domestic engineer in about a week.

* * * * * *

Mr. P. is next about to apply to the Southampton Railway, and I am now preparing letters* for him to make use of, setting forth that, when once laid down, the Admiralty will, no doubt, be glad to make advantageous contracts with them for the use of it for Portsmouth, which is at no great distance.

We must, of course, rake our brains to find out all the inducements we can to tempt people to these speculations.

That will be the next move. Then there will be the grand junction from Birmingham to Liverpool and Manchester.

The next business man I hope to retain, and have partly, is Captain B——. He is intimate with the engineer of the Birmingham and Gloucester Railway, and has influence with the Midland Counties Railway, either of which would be a good step.

Another is Mr. B——, of whom you have heard before.

* * * * *

I have an appointment to meet a capitalist, name as yet unknown, at three o'clock on Monday about money for taking out the foreign patents, all which may, or may not, come to nothing. Another appointment with a broker, named L——, to aid in getting up a company, at four o'clock the same day. There are many of these appointments for the one that leads to any result. Therefore, do not be on the look-out for such results, I will be sure to tell you if anything good comes. It is no use to be either sanguine, or easily put out of one's opinions.

Believe me, my dear Father,

Your ever affectionate son,

E. DAVY.

P.S.—My impression at this moment is that it will be better, if possible, to get up a general company, and sell the patent out and out, particularly as the Birmingham directors scarcely appear to comprehend the advantages of the system further than for mere railway uses. It will, I know, be a very difficult matter to get the proper people in the mind for entering into such a scheme. Mr. Hesseldine appears to listen to the proposition, but has some objections of which I cannot clearly see the drift, unless it be this—that the Government could scarcely allow such a powerful instrument to be in the hands of individuals, or a private company, and would either prohibit it, or else take it under their own management; and, therefore, that the best possible parliamentary, or government, influence ought to be made in order to secure the probability that such future arrangements with the Government may be advantageous to us.—I know very well that the French Government would not permit it except in their own hands; but though I think our Government ought, *and, perhaps, will eventually, take it upon themselves as a branch of the Post Office system,* yet I can scarcely imagine that there would be such absurd illiberality as to prohibit, or appropriate it, without compensation.

There is, however, prudence in what he suggests as to making friends in high places, if it can only be done.

Are there any of the Directors of the Bristol and Exeter Railway with whom interest could be made? They are, I believe, in great part Exeter people.

4 July, 1838.

My Dear Father: It was not until this morning that my patent actually passed the Great Seal. It is now secure for England and Wales, and you will see it in the list in the next *Gazette.*

The enclosed was written some time back. It may be well to preserve whatever details I send you with regard to the telegraph.

My object now is to get a company formed to take my patent off my hands, and, either pay me a large sum down for it out and out, or else a smaller sum down, and an agreement for a further remuneration hereafter, and proportioned to the success of the scheme, such as a percentage on dividends, etc.

* * * * * *

There is plenty of money in the market, and plenty of people ready to vest it in such schemes, if they can only be satisfied that they will pay more than 5 per cent. interest. All I have

* A few letters to and from business men and Railway Boards on this subject are preserved amongst the Davy MSS.

* Original drafts of these preserved.

to do is to make people believe this, and the money will come without any pressing on my part. But this *is* the difficulty, and one which I have now to make every possible exertion to overcome. The practicability of the plans will, I believe, not be much longer doubted. I have several persons at work to get some influential names sufficient to head a prospectus* as Directors, &c., and find current expenses of printing, advertising, journeys, models, &c.

* * * * *

Mr. P. says that "before forming a company, we must first secure the consent of some railway company to the laying down of the wires upon their line on certain terms. If one railroad will do this, we may afterwards reason that others will agree to the same; otherwise people will say, 'How are you going to enforce permission from the railways, or turnpike trusts, without an Act of Parliament'?" Now, I don't see that the want of previous agreement with a railway should at all deter us from endeavouring to form a company, but it is clear enough that such an agreement, previously obtained, would be a step gained, and an argument in our favour. With this view an appointment is now pending with the domestic, or resident, engineer of the Birmingham Railway.

* * * * *

I have had notice of another application for a patent by a person named *Morse*. Messrs. Cooke and Wheatstone have entered an opposition to this application, and I shall have to do the same, so that one, or other, of us may be able to stop it. We are now both equally interested in keeping a third rival out of the field, and it may save much after trouble and competition. * * * * *

Your ever affectionate Son,
E. Davy.

In a letter to the same address, dated July 21, 1838, the following passage occurs:—"I find the people who undertake to make appointments about the telegraph very dilatory in so doing, which prevents my making progress as fast as I could wish. I trust the prospectus will be a help.

"It is not every one who is willing to be a director that will suit, as I wish to confine it to the highest respectability, and avoid all poison. Mr. E— has evidently his enemies, but if I can find that he has also his friends, he will be a valuable acquisition, having much money and connections, and I believe he would liberally support me, or lend his voice to pay me a large sum."

Two days later he wrote:—"I had a further conversation with Mr. P— on Saturday. He expects an appointment with the engineer in question [? Mr. Fox] on Tuesday, and entertains a hope that we may also secure Mr. —, the chairman of the Southampton Railway Company, than whom, for one, we need not have a better. Mr. P— having considered the prospectus, and suggested some slight alterations, said that, now the thing was distinctly laid out, his views had quite altered, and he should have a difficulty in seeing how the thing should do otherwise than 'pay' to the shareholders. He would be the managing director, or whipper-in, as he is in the A— Mining Company. As I have but slender acquaintance among the great commercial people, I am obliged to apply to, and make use of, persons of this kind, and I believe he is well known and knows many, and that his persuasion may have some effect, where I should not be listened to. The difficulty is to get him to stir himself sufficiently. I do not anticipate much good from either Captain B—, or Mr. B—, but perhaps they may be of some aid."

30th July, 1838.

My Dear Father: * * * * * I had an interview on Wednesday last with Mr. Fox, Resident Engineer of the Birmingham Railway, the whole particulars of which I can scarcely enter upon at this moment, except that it was quite satisfactory and friendly, as far as it went. The main purport of it was that if we had a Company who would go to the expense of laying down the wires, &c., the railway directors would willingly grant the use of their line and afford every facility and protection, on condition only of a license under the patent as far as relating to railway purposes only.

This has been one of the problems, "How is the Telegraph Company, without an Act of Parliament, to lay down the wires?" He says there is no doubt that few of the railway companies will object to these terms. Mr. P— has promised to-morrow to see the Southampton Railway people, and I shall have another interview with Mr. Fox, for further explanations, so that I trust we shall soon be enabled to come before the public; but it is a tedious business. 31st July.—Since writing the above I have received M. A.'s letter and enclosure, to which I shall give the earliest attention. You may presume, if you do not hear from me for some little time together, that there is nothing particular going forward. I understand the directors of the Great Western Railway are under discussion to ascertain the nature of my patent, but I shall take no notice at present.—With kindest love, believe me,

My dear Father,
Your ever affectionate Son,
E. Davy.

In a postscript to a letter dated Aug. 1, 1838, he writes:—

"I spent yesterday evening with Mr. Fox explaining my inventions to him. He expressed the most favourable opinions of them, and, if he does not alter his mind, we may consider the Birmingham line as secured, or nearly so. He is the sharpest and quickest man I have yet had to talk to, comprehending everything before it was half explained, and suggesting improvements, or remedies for difficulties, &c. We are in other quarters making slow but, I trust, effective progress, and the chances against eventual success appear daily diminishing."

17th August, 1838.

My Dear Father: Mr. P. has had interviews with Mr. Easthope and his son. Mr. E. seemed to take very enlarged views of the applications of the telegraph, and the revenues to be derived from it, and promised his strenuous influence for its immediate adoption on the Southampton and Portsmouth line, of which he is chairman of the directors. The conversation, as repeated to me, coincides with my own (perhaps sanguine) idea, to an extent which I have never had the satisfaction of meeting with before. Mr. P. came home quite red-hot upon the matter, sees it in a new light, and has this morning agreed to take out the principal foreign patents (to find the money and have half), on condition that I would also give him a further interest in the English patent already obtained. I have, consequently, agreed that he shall pay me £150, and have one fourth of the patent right. This I have done, not but that the patent may be worth far more than four times £150, but with ulterior objects, to secure his interest and exertion to help it on, for I could do little by myself. And it appears to me the remaining ¾ may be thereby increased in value more than they will have lost. I do not suppose that Mr. P. will go from this arrangement, which yet remains to be executed. He says, that, if sufficiently interested, he will devote nearly all his time to it.

I spent yesterday evening and took tea with Mr. Fox, resident engineer of the Birmingham Railway. I have his decided approbation of my plans, in preference to those of the other party, and, therefore, a powerful voice is secured on that line. We had much conversation on various details of the subject, but it takes time to work people into an acting humour. Until now Mr. P. has been lukewarm, or, at least, tardy, in his movements. The encouragement, which Mr. Easthope has given, has put a new life into the thing.

I believe I told you that Mr. Easthope is a Member of Parliament, proprietor of the *Morning Chronicle*, and a large shareholder in the Southampton, and in the Havre and Paris Railways. He is, perhaps, as good a patron as could be obtained for one. He said that the subject was not new to

* A draft of such a prospectus, headed "Voltaic Telegraph Company," is preserved in the Davy MSS. It is a powerfully-written and exhaustive document, and will well repay perusal. *Apropos* of the name, the following memorandum may be quoted:—"A satisfactory name is not yet decided on. It might be called the 'Oerstedian,' after Oersted, the Danish philosopher, who first discovered the magnetic powers of electricity; or the 'Instanterian;' but a better name may turn up." In another place Davy speaks of a system of *Electroloquism!*

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him, and that it had been frequently under discussion in society where he had been.

You will perceive that if I have been in error as to the prospects of this invention, I have now some people of high standing to keep me in countenance in the "moonshine." Mr. Easthope speaks of its opening communications between London, or Liverpool, and the Mediterranean! With kindest love to all the circle, believe me, my dear father,

Your affectionate son,
E. DAVY.

About the end of August, or beginning of September, 1838, he wrote

My Dear Brother,—

I have just received a packet enclosing, among others, a letter from you. You will perceive by my communications to father, &c., that I am trying hard to dispose of my telegraph. I wish to get it clean off my hands, and, if possible, an employment in laying it down at an annual salary. I believe I may now almost calculate on the Birmingham Railway, the best line in the kingdom; there is little now to fear from the rivals, Cooke and Wheatstone, and there are no others. My object is to form a company of affluent people, who will purchase my patent right, and, if this succeeds, it will produce a large sum of money, as £10 or £20,000, just as easily as so many hundreds. The value of the invention has very greatly increased since what it was six months ago, and I would not now sell it to Cooke and Co. for any sum they would be likely to offer, and which I would gladly have accepted once. I have every assurance that I shall get together a set of wealthy directors, and that the shares will be taken up. We have, as you will perceive, some first-rate people already engaged, and much interested in it. Mr. Wright could, if he chose, advance £200,000. We are promised the Marquis of Douro and Lord Sandon for trustees, through the interest of Messrs. MacDougall, the solicitors in Parliament-street. There is no present reason to apprehend but that I shall get my price for it by persevering and securing influence step by step. But for all this, my presence here is indispensable. It would come to nothing if I left London at this juncture which would be madness. There is no one able, or willing, to push it forward for me, and, if allowed to sleep, the patent would not be worth a rush. I am now anxious to connect with some sharp, wary solicitor, not too young, whom I can engage to protect my own personal interests in driving the bargain with the directors, which will be very essential—one is so apt to be talked over by these keen monied men.

* * * * *

The enclosed piece of paper contains a statement of the progress made in organising our company. Only the names with asterisks are fully secured, but the others we have not much reason to doubt of.

When a meeting of the directors can be called together, I shall propose that as soon as the deposits are paid up they give me £10,000 in money and one or two thousand shares; in fact, the best bargain I can make. Something will come of it.

Your ever affectionate brother,
E. DAVY.

P.S. Exeter Hall cannot be said to pay at present. It is kept open rather to answer a purpose in getting up the company.

The above letter, as appears from another to his father of September 9, 1838, was written to his brother, Henry Davy, about the end of the previous month.

The piece of paper referred to contains the following:—

TRUSTEES.
Marquis of Douro, and Lord Sandon.

DIRECTORS.

*Sir F. Knowles, Bart., F.R.S.	Mr. Bagge (of Norfolk), M.P.
*John Wright, Esq., Banker.	Mr. Harrison (Chairman of the Southampton Railway
Em Tennant, Esq., M.P.	

ENGINEER.
Mr. Fox.

SUPERINTENDENT OF MACHINERY.
E. D.

SOLICITORS.
*Messrs. M'Dougall and Co.

Capital £500,000 in 10,000 shares, £50 each, deposit £5.

In a letter to his sister, dated September 22, 1838, he says:—

"I am obliged to remain in, or near, London on account of the telegraph, as there is a probability that the arrangements with the Southampton Railway will soon be completed. Nothing is certain as yet, but the Directors appear decided upon having one on their line. The Birmingham line also is in prospect.

"I have sent a circular to all the principal Railway Companies. The Grand Junction say they have no intention of adopting any telegraph at present, and the Birmingham and Derby seem to imply, in their answer, that they have it in contemplation, and will take it into consideration as soon as they are prepared to do so, &c. All that could be expected from the circular was to prevent them from engaging with the other party before they knew anything about me.

"The idea of forming a Company is suspended for the present, on account of the opinion of the Southampton Railway Directors, that all the railway companies would eventually take it upon themselves and find the capital. If so it is all that is wanted.

"I presume that if terms are made with the Southampton, which is the first company that is likely (being on the line of the Government Telegraph to Portsmouth, and having a probability of a contract with the Admiralty), they will require me to superintend the laying it down at a salary, independent of the remuneration for license under the patent."

On October 8, 1838, he writes to his father:—"I have done all I can to bring my patent before the Southampton Railway Company, and have received every assurance as to their intention of adopting it. I must now wait their final decision if they do so, as to the precise terms, and also as to the time when they will be ready to commence operations. What I have proposed to them is, that they shall be at all the expenses, pay me one-third of the net profits, and employ me, at a reasonable salary, to lay down the telegraph and keep it in repair.

"I will shortly make an attempt to urge forward the Birmingham Company, where, I believe, I have sufficiently secured the preference. As soon as one of these companies brings the telegraph into operation along the entire line, and it is found to answer, the others will quickly follow.

"The Polytechnic Institution, after giving much trouble, declined purchasing the Exeter Hall model, and I am now in treaty for it with a Mr. Coombes, an American, who proposes to take it home with him, and open an exhibition, with some other models, in his own country. I have closed the Exeter Hall room, and paid off Mr. Spicer, my assistant, and also Downy, the other man who used to attend there."

Again on November 17, 1838, he says:—"I have made some arrangements with Mr. Watson, rather on the principle of co-operation than of actual partnership, and have pretty well explained to him how I am situated. * * *

"You will perceive I am anxious to be doing something, independent of my expectations from the telegraph. I have put it into as good a position as possible, and have no doubt of its final success; and must now wait the answer from the Southampton Directors, who have verbally promised its adoption, as well as from other quarters. I shall not let the matter go to sleep, but as it is in a channel, and as my interference will not hasten it, there is little to be gained by thinking of it; so I must be doing other things.

"There is no relying on Mr. P. He agreed to purchase a fourth of the patent for £150, and was red-hot to conclude the bargain, but after a few days he told me that he could not at present provide the money? I cannot help these disappointments.

"Mr. Fox is steadily friendly to me as yet."

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29th Nov., 1838.

My Dear Father: * * * * I have got rid of my room at Exeter Hall, which, now it is no longer required, is a saving of 14s. a week. Altogether it has somewhat more than paid its expenses, or thereabouts. It would doubtless have done better, but I was driven from personally attending to it by incessant annoyances. It has, however, answered more effectually by the notoriety which it has given to the telegraph. You will perceive by a number of the *Railway Times* which I shall enclose, a reason for the delay in the decisions of the Southampton Company, viz., the question whether they would obtain the branch line to Portsmouth. Mr. Easthope is a spirited man, by whom many other monied persons are guided, and he has influence with the present Government. I have as yet no reason to doubt that he will keep his word with me, that my telegraph shall be adopted immediately they are prepared to commence operations with it. The bringing this to bear may be a work of some little time, as such things usually are, but I am sure you will not regret the attention I have paid to it, nor even the manner in which it has diverted me from my other business; nor do I think you need feel doubtful as to its eventual success. The next month will be occupied with completing the specification (due Jan. 4), much of which will have to be remodelled by Mr. Carpmael's direction. Everything depends upon this being as perfect as it can be, and I wish I were more fit for the task, by having a mind more at ease than is at present possible.

* * * *

I have to-day been informed that the Brighton Railway Company are about to adopt an electrical telegraph, which is a quarter in which I scarcely expected it. I must look after them to ascertain if it is correct, for Mr. Cooke is making all his interest. I think the London and Dover will be a better line, but will not be complete for a long while. I am obliged to employ a good deal of Nickolls' time on the working model, which will be the principal thing in the specification, in order that it may be ready to show at work. The month after the specification is enrolled it will appear, at length, in the *Repertory of Arts*, a number of which I shall purchase and forward to you. With kindest loves to mother, brothers, and sisters, believe me, your ever affectionate son,

E. Davy.

December 12, 1838.

My Dear Mother: * * * * * My specification must be enrolled by the 4th January, and afterwards will be published, gratuitously, by the patent agents, in the *Repertory of Inventions*. This also I shall have to look to, procure a few copies, and send them to the parties most likely to serve us. After this, for aught I know at present, there is little more I can do to forward the matter, and it must wait the good time of the railway directors to take it up, which there is no reason to doubt nearly all of them will do eventually.

I believe I have effectually barred any hasty adoption of Cooke and Wheatstone's telegraph, which has made no further progress.

You must be aware that, although it may come into operation almost immediately, yet it may possibly not until some little time hence; but this is a question which now rests with others, and not so much with me, and we must not, therefore, be disappointed at some delay.

* * * * *

Your ever affect. son,

E. Davy.

We have arrived at the end of our MSS, and, consequently, at the end of our task, which, we need hardly say, has been to us a labour of love; but before laying down our pen we cannot resist the pleasure of quoting two short passages, which will serve to show in what estimation Mr. Davy was held by those most capable of comprehending his character. The first is from a Mr. Thomas Watson, London, a gentleman of great scientific attainments, to Davy's father:—

May 20, 1839.

My Dear Sir: I have to apologise for not acknowledging the receipt of your kind present ere this, an exceeding pressure of business must plead my excuse.

Permit me to say that any service I may have rendered your son has been to me a source of much gratification. I much regret, upon private grounds, that by his absence I lose an acquaintance which I highly prized, while, upon public grounds, science has lost an adjunct as talented as zealous, and, without flattery, I must add *his pursuits would have so enlightened and benefited his countrymen that his secession to the primitive shores of South Australia must be deplored as a national calamity.*

* * * * *

Believe me yours sincerely,

Thos. Watson.

The next extract is from a letter (October 21, 1839), of Charles Pain, the family solicitor, of Surrey-street, Strand, to the same address:—

"Mr. Carpmael passed some high encomiums on your son's talents in matters of science, and said he considered *his leaving England a great loss to the country*, and he particularly regrets his absence on account of the telegraph, which, had he been present, he would have had no difficulty in disposing of to the Great Western Railway Company, who are now adopting that of Messrs. Cooke and Wheatstone, and to whose, he says, your son's is very superior"

The rest can be told in a few words. For a year or two after Davy's departure for Australia, his father and one or two friends tried, but in a half-hearted way, to carry on the negotiations from the point where he himself had left them. Another exhibition of both the screen and recording telegraphs was opened in Exeter Hall for a few months in 1839-40, but, as those in charge of the instruments did not thoroughly understand them, and could not always get them to work satisfactorily, no good came of it.

The machines were sent down to Ottery St Mary at the end of 1840, and were stowed away in an out-house as so much rubbish. In the hope of rescuing them we lately paid a visit to Davy's native place, but found, to our grief, that only three years ago, on a change of residence, they were broken up and sold as old metal! Our informant, the family gardener, added "'twas such a pity, as there was as much mechanism about them as would fit up a hundred clocks!"

In a field we found some pieces of cotton-covered iron and copper wire, and six of the Daniell cells—huge things of three or four gallon-capacity. The outer jars are of glazed earthenware about eighteen inches high, and the porous pots are more than half an inch thick! These relics will now be carefully preserved.

And so ends the story of a *magnificent failure.*

Overhead Wires.—"Perhaps we had better not be in too great a hurry after all," says the *Globe*, "to get rid of the overhead telegraph wires. If they are a source of danger in one direction, they may, if the President of the Society of Telegraph Engineers and Electricians is not mistaken, conduce to our safety in another. It is not only Colonel Webber's opinion, but, according to the *Globe*, seems to have been that of the majority of those who attended the Electrical Congress at Paris in 1881, that the overhead wires may have the effect of dispersing electrical tensions above them, and, further, if a discharge takes place, may interrupt and convey it away. They may unfortunately carry it a long way, and with disastrous results. Colonel Webber has seen a man at work among telegraph wires thrown to the ground by a lightning shock from a storm twenty miles off. At the time he was struck there was not a cloud above them." For our part we do not see that it matters much whether the wires carry the lightning far or near, and the inference to be drawn from Colonel Webber's own illustration is rather against having wires very near you during a thunderstorm. The *Globe* should have spoken of Colonel Webber as a past president of the Society; but these little slips are to be expected.

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THE ELECTRICIAN.

TO CORRESPONDENTS.

All letters intended for insertion in THE ELECTRICIAN, *or containing questions, must be accompanied by the name and address of the writer, not necessarily for publication, but as a proof of good faith. No notice whatever will be taken of anonymous communications.*

All communications to be addressed to 396, *Strand, London, W.C.*

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ANSWERS TO CORRESPONDENTS.

W. H. P.—*Send your present address.*

A. A. C. S., NEWCASTLE-ON-TYNE.—*No objection, if acknowledged.*

J. J. RATHBONE.—*We cannot pretend to decide as to the plan suggested being an infringement or not. The question is one for the patent agent; but if we might advise, we should say do not spend one single penny with the patent agent in any way.*

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THE ELECTRIC LIGHTING PROVISIONAL ORDERS.

Disappointing and inconvenient as it undoubtedly was, the result of the recent debate on the Electric Lighting Provisional Order for the parish of St. James is not greatly to be wondered at. Mr. Chamberlain had himself raised the spectre of monopoly in the early stages of the Electric Lighting Bill, and had kept it above ground all through the discussion. When, therefore, the provisions came to be applied to a particular case his political opponents, as well as the opponents of electric lighting in general, combined to frighten him with his own ghost. This is really the explanation of the wrangle over the question whether the committees to which the confirming Bills are to be referred should be empowered to hear parties against the Bills irrespective of their *locus standi.* The astonishing zeal in the affairs of a West End parish, and the anxiety to prevent a monopoly displayed by persons not usually supposed to be averse to the principles of monopoly, admit only of one explanation, namely, that the President of the Board of Trade having furnished the rope, there were plenty of people only too delighted to hang him with it. Mr. Chamberlain refused to be hanged; he yielded instead.

The consequence of this discreet though inconsistent surrender on the part of the Board of Trade is that parties may, and probably will, be heard in opposition to every confirming Bill presented to a parliamentary committee. These parties will represent interests of various kinds; first, the local inhabitants may appear over the heads of their duly elected local vestries; next there will appear the parties representing, indirectly of course, the gas interests; thirdly, there is the Metropolitan Board, which assumes to represent everybody; and lastly, there are the competing electric lighting companies, some of whom, strange to say, are ready to upset a settlement made with one company in order that a cheaper one may be entered into with themselves. This it will be said is competition carried to the utmost limits of freedom; but Mr. Chamberlain, being pledged to free competition, and sworn to prevent monopoly, was finally compelled to agree to let the parties be heard. There was no gainsaying the logic of the suggestion, if the logic on which he had argued the original Bill was sound. It was in a spirit highly hostile to monopoly that the measure was forced through Parliament, and a mere counterfeit of the same spirit threatens to wreck the measure.

We never cordially approved of the original Bill, but for once we are able to agree with the parent of it, who now finds that unreasonable uses have been made of his favourite arguments. He urges, and very properly urges, that to admit a competing company as petitioner against another company already in possession, and requiring only a confirming order, is practically to re-open the whole question, and in fact to set no limits to the obstruction of petitioners. It is a pity he did not see this before. In this way, said Mr. Chamberlain, they might go on hearing objections as long as there were any promoters, speculative or not speculative, offering to do the work more cheaply. The difficulty of making choice was what we foresaw from the very first, and it is one that could only be settled by free competition in the first instance untrammelled by any provisions against a possibly resulting monopoly. Mr. Chamberlain ought by this time to know perfectly well that none but speculative promoters would risk very much where a practical monopoly is not well nigh certain. If that is denied, then the legitimate reward of successful merit is withheld, and except for experimental purposes the really meritorious systems will not compete at all.

As to the action of the Metropolitan Board, it is as mysterious as the inaction of the Public Prosecutor. The last named personage has a soul, whereas boards are commonly said to have none. Perhaps that is the reason the one is willing to rest in contented obscurity whilst the other is always fussily anxious to prove its vitality. The Metropolitan Board, at all events, can have no other rational motive for interfering between the local authorities and the promoters whom they have chosen to light their districts. Of course, there is the well worn plea that the vestries are in danger of conferring a monopoly. With the experience the Board has had of raising loans one would have thought it might have learnt by this time that, except for the support of *monopolies,* open or disguised, loans would be very difficult to obtain.

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Whatever may be the motive of its interference in this matter, whether to prevent fresh monopolies or to protect those already existing, the effect will be to delay the progress of electric lighting, and possibly to prevent its legal standing being confirmed in this present Session altogether. Most of the newspapers commenting on the interference of petitioners led by the Metropolitan Board seem to anticipate this result, and to deplore it. We, for our part, while we regret the delay, see in it only a fresh proof of the radical defect of the original measure, a measure that was carried in haste, but may be amended at leisure.

Since writing the above paragraph we learn that the Metropolitan Board of Works have withdrawn the whole of their petitions, and will not appear in any way before the hybrid committee. We are glad to welcome this complete change of front, even at the eleventh hour, but it cannot be forgotten that the opposition of the Board has greatly stimulated other opposition. Electric light engineers know that the greater part of the opposition is directly and indirectly from the holders of a gigantic monopoly—that of gas. It is no secret that money is being lavishly expended to further the ends of the monopoly, and to wreck the progress of the electric light. We do not believe that the attempt will be successful, nor do we think the gas interests will gain any credit at the conclusion of the contest.

CORRESPONDENCE.

MEDICAL ELECTRICITY.

TO THE EDITOR OF THE ELECTRICIAN.

Sir: Reading the correspondence lately published on the above subject, and having had some practical experience in this direction, I beg to say a few words in favour of electricity as a curative agent in many cases, if properly applied. Most of the systems in use do not have the desired effect; they simply excite a few muscles, but do not penetrate deep enough into the internal parts of the body to cause a destruction and restoration of the equilibrium of the nervous, muscular, and other fibres. We know the most important parts of the body consist of capillary actions, and if some of these capillary tubes become stopped or choked up by foreign matter the result is illness in some form or other. We all know the action of electricity on capillary tubes; how beautifully it causes each molecule of conducting matter to repel each other, which gives us direct motion in the capillary tubes, a motion which could not be obtained by any other means so quickly. I cannot think we get this effect by the use of a coil or magneto machine applied externally. This method may be beneficial if the complaint or disease is very near the surface, but it will not penetrate the internal parts of the body. What we must do is to cause a through action to all the working organs of the system, so as to clear and set to work parts that have become corroded or impregnated with some foreign matter decomposed. This matter, set it free, and it will work out of the system through the blood, skin, &c. In cases of gout, paralysis, rheumatism, sciatica, nervous debility, and many other complaints, relief is the rule, not the exception. The only way of using electricity as a curative agent is by means of the electric bath. I say this, as it is by the use of these baths I have seen some good work done. I have seen neuralgia, toothache, cramp, fits, and similar temporary and local pains relieved by the external application of coil or machine, but I have not known this external application of the coil to give speedy relief or cure a long standing gout, rheumatism, lumbago, or do any good work in liver complaints, paralysis, or give speedy relief in cases of prolonged, or suppressed, condition peculiar to females, that the continued use of the electric bath will give in almost every case, and sometimes effectually cure. Some years ago I fitted up a number of these baths, and had every opportunity of watching the results, which I have done. There are two systems in use—one is known as Caplin's system; the other is known as Potin's system. Caplin's system is by the use of batteries alone, and a copper bath in which sulphuric acid and water is used. The patient lies on a wood frame, to keep him from contact with the bath, which is the negative pole; a brass rod is grasped by both hands outside the bath. This is the positive pole. The battery consists of from 10 to 30 one gallon cells. The elements are carbon and zinc, arranged as in Smee's cells, the electrolyte sulphuric acid one to seven of water. The batteries are fitted with a winding arrangement for lifting the plates out of the solution. Other forms of cells are used, but this form is preferred on account of the large quantity of current obtained. Potin's system is on a different principle. It is with this system I have seen some very good results obtained; this system was very successfully used by M. Adolphus (now deceased) in the West End for some years. The bath in this case is of slate, or some non-conducting material. Water is used as in the ordinary warm bath; the addition of some sea or bay salt is good. A coil is used with this system, which is a primary one of large capacity; the coil is wound with 10lbs. of No. 8 or 10 cotton covered wire. It has the ordinary contact breaker at the end of the bundle, and brass sliding tube to regulate the intensity. The battery consists of a one gallon cell; the elements are a prism of carbon in a porous pot, and a cylinder of zinc, the electrolyte a weak solution of bichromate of potass and sulphuric acid. Instruments or conductors are used for some complaints. As a rule the current enters at the head, or back, of the bath, and returns from the foot. These baths are very pleasant and refreshing if the current is not too strong. It is recommended that the patient should take at least 12 baths, as it sometimes happens that the first few baths develop up the complaint, and the patient is slightly worse, but the continued use of the baths will give relief, and very often effect a cure of many diseases. I shall be happy to forward further particulars or drawings of these baths.—Yours, &c., H. A. Kent.

154, Culford-road, N., July 14, 1883.

PROVISIONAL PROTECTION.

TO THE EDITOR OF THE ELECTRICIAN.

Sir: It appears that the period of provisional protection in the forthcoming Patent Amendment Act is to be extended to twelve months. This, in my opinion, will be adding six months of anxiety to the present unsatisfactory arrangement experienced by inventors, especially by those of limited means.

The amount of systematic dodging and organised swindling that the so-called provisional protection admits of is too well known already. The poor inventor would stand much less risk if the law necessitated the filing of a complete specification, and so settle the matter at once.

On scientific and legal grounds discoveries and inventions should be clearly defined at the date of filing, so as to leave no doubt as to who is the first in the field. What right, I would ask, has an inventor to apply for a patent for an invention before he is able to define the novelty of the particular machine forming the subject matter of his application? A, a capitalist, might file an application for improvements, &c., in certain apparatus. B, an inventor, might also do the same a few days after A, for improvements in the same direction, but essentially different from A's invention. As B would probably require assistance in the development of his invention, he might go to A, and the latter might, with the aid of skilful assistance, include the invention of B in his own final specification, and so claim priority. It is true that the final specification is supposed to be substantially the same as the provisional; but that is a matter that would have to be decided in a court of law, when B, having no capital, would, I am afraid, stand a very poor chance.

Provisional protection suits the well-to-do manufacturer

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and "adapter" rather than the "first and true inventor," whilst it is a powerful weapon in the hands of the unscrupulous.—Yours, &c., INVENTOR.

THE GRAMME RING.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: On referring to Mr. Mordey's letter in *The Electrician* for May 5, I find that (for some reason unknown to me) I *had* misread the latter part of his communication. Had I referred to your publication at the time of writing the mistake would not have occurred.

Mr. Mordey says:—"I found that with four poles the product of current and E.M.F. in the external circuit was a *little more than* 100 per cent. greater than when two poles were employed." This means an increase of about 45 per cent. only in the E.M.F.!

It may be worth noticing that in a Gramme ring of ordinary construction, the thickness of wire on the outside is much less than would obtain if the same wire were put on to a flat core of the same mass and sectional area, and consequently the field magnets may be considerably nearer the iron, a condition obviously favourable to induction from one side.—Yours, &c., W. B. SAYERS.

Cambridge-street Works, Birmingham, July 17.

PRACTICAL TELEPHONY.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In your issue of June 16th I see in the article on "Practical Telephony," page 114, the action of the telephone described thus:—"The action of the telephone depends on the well known principle that when a coil of insulated wire is placed on the end of a permanent magnet, or its soft iron pole piece, any movement to or from the pole piece of an iron armature induces a current in the coil of wire. . . . . If the diaphragm be spoken against it vibrates in unison with the voice, and as the diaphragm is the armature of the magnet, corresponding undulating currents are generated in the coil of wire surrounding the magnet." My understanding of the action is, that the vibration of the diaphragm *does not induce a current in the coil by its vibration*, but modifies or regulates the flow of the current by its approach to or recedence from the core.

Having only crude instruments to experiment with I cannot get as good results as if I had perfected ones to work with. The experiment I made to demonstrate my theory on the telephone current was made by using one Bell magnetic telephone and ordinary telegraph key; the terminals of the telephone were grounded in a moist clay soil 60ft. apart with key inserted between one terminal and ground wire. When the key was pressed down I could hear a click, caused by the diaphragm being attracted by the core, and on opening the key could hear a click caused by the diaphragm springing back to its normal position. This convinced me that there was a current at all times not caused by the vibration of the diaphragm, the current commencing as soon as the magnet pole was surrounded by insulated coil of wire an induced current of uniform flow, *but made undulating* by vibration of the diaphragm when used as a transmitter. I thought at first that the current might have been caused by a difference of potential at the grounding, but an electrician informed me that that was too small a distance to get a difference in.

If I am mistaken in my theory will some reader please carry out the experiment, and inform me through the columns of *The Electrician* the result.—Yours, &c.,

Bryan, O., July 5, 1883. W. E. KAUKE.

MANCE'S METHOD.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Referring to the note on Mance's battery test in your last issue, let me point out a slight error occurring in Mr. Barker's last calculation, not, however, interfering with the proof. The total deflection (596·16) should be divided by the ratio $\frac{19{\cdot}09}{10}$ instead of $\frac{19{\cdot}09}{9{\cdot}09}$ to obtain the galvanometer deflection when they closed, which is, therefore, 312·3 divisions.—Yours, &c., H. D. WILKINSON.

School Electrical Engineering,
12, Princes-street, Hanover-square, W., July 16, 1883.

NOTE ON CURRENT ENERGY, &c.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: To Mr. Heaviside's admirably simple and elegant discussion of the relations between E.M.F. and current vectors let me add a very simple little result as a corollary. In the case of any conducting medium, if the E.M.F. vectors corresponding to current vectors in any three rectangular directions are coplanar, the E.M.F. vectors corresponding to currents in *all* directions will be in the plane of the first three.

If η be the E.M.F. vector corresponding to the current vector ω, the general relation between these is,

$$\eta = -\eta_1 S\, i\,\omega - \eta_2 S\, j\,\omega - \eta_3 S\, k\,\omega,$$

or

$$\eta = \chi\,\omega,$$

where χ is a linear vector (but not self-conjugate) function, and (i, j, k) are rectangular unit vectors, while η_1, η_2, η_3 are constant vectors. Operating on this equation successively with $SV\eta_2\eta_3$, $SV\eta_3\eta_1$, $SV\eta_1\eta_2$, we find that, if $S\eta_1\eta_2\eta_3=0$, η must tie in the plane of $\eta_1\eta_2\eta_3$. In general

$$\omega = \frac{1}{S\eta_1\eta_2\eta_3}(i\,S\eta_2\eta_3\eta + j\,S\eta_3\eta_1\eta + k\,S\eta_1\eta_2\eta),$$

which deduces the current from the E.M.F. vector.

Mr. Heaviside then goes into matters which, though not deducible from the equations of the subject, possess a strong interest, at any rate for me. The design argument can be vastly extended and illustrated in even pure mathematics, just as Mr. Heaviside (to whom, therefore, the theologians are deeply indebted) has shown that it can be in the consideration of Ohm's law, and the fearful consequences which would result from its invalidity.

Mr. Heaviside (no doubt with recollections of *Patience*) says, "Conceive, then, if you can, the electric light young man." I can conceive him, but I prefer at present to refer to an archbishop, who two or three years ago delivered to his clergy a charge which was meant to be a supreme criticism of science based on the most authoritative knowledge, to assure his clergy and the public in general that the heads of the Church kept pace with the foremost scientific ideas. There was, however, a poverty of illustration, at least in the electrical department of the charge; for the archbishop, mounting to the summit of eloquence and scientific knowledge, exclaimed, "I may admire your electroscope as a scientific wonder, but beyond it there is something," &c., &c.

If bishops and archbishops take Mr. Heaviside's hint, they can compose magnificent charges with very little trouble by taking up a few of the less known laws and facts of science—say conical refraction and the law of Lenz—in the way pointed out by Mr. Heaviside. Electroscopes are, no doubt, mighty instruments in the hands of science, but they are not now sufficiently impressive; for it is possible that even some school girls may be present who will recognise the name when it is trotted out for effect.

GEORGE M. MINCHIN.

R. I. E. College, Cooper's Hill, July 18, 1383.

INTERNATIONAL FISHERIES EXHIBITION.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: No practical man who has seen the electric machinery at work at the International Fisheries Exhibition but has been struck by the terrible overloading of the engines. A breakdown more or less serious is at any time not only a possibility, but is *inevitable*. It is then the usual cry will be raised, "Oh! the electric light is not to be depended on,"

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and by the general public the *light* will be condemned, while the real fault lies at the door of the engineers. Already your contemporary the *Engineer* (in its issue of 22nd June) has saddled the wrong horse. "The *electricians*," it says, "have, *as usual*, underrated the power required to drive their machinery." Note the "as usual," and be sure that at the first serious breakdown there will be a chorus of, "We told you so" from the real culprits.

The old time remedies have been tried—heavy belts, regardless of cost, and these tightened up till life and limb are seriously endangered. Already, not once or twice, but half a dozen times, the over-stretched belts have given way, and where they do not give way the whole time of the engine drivers is devoted to keeping the shafting cool. It is under these circumstances that I have made an offer to the Exhibition Committee, and to the engineers an offer that I now repeat, and it is this: I will prove and demonstrate that the electricians have *not* underrated the power required, but that the power that is now being lost or wasted through defective transmission is more than sufficient to actuate the whole of the dynamos without tightening the belts and without overworking the engines as they are now overworked, at the momentary risk of a grand breakdown, to the prejudice of the electric light. In other words I will save power or increase the efficiency of the motors to the extent of at least 25 per cent. I propose to do this by the application of Samper's patent pulley grippers, which I will put on and take off again *without charge* if they fail to accomplish what I have undertaken, but for which I ask *net cost price* if they succeed.

Says Mr. Paxman to me to-day, "If you can do that I will give you the whole of this installation of engines and boilers; but the principle of your system is old and well known, and is nothing but a belt tightener, and would actually load my engines more than ever." Now, with the gripper I work with *looser* belts than any other sytem, and I have illustrated this on Messrs. Davey, Paxman, and Co.'s own engines at the Crystal Palace. I hold the testimonial of Mr. Brockie, of the British Electric Light Company, who says: "Before the application of the gripper we were much troubled with hot bearings. With the gripper this was *entirely obviated*." "Still," says Mr. Paxman," it looks like a belt tightener, and so it must be one." Now, on the other side of the water, where I come from, when we find a man persisting in a wrong-headed opinion, we ask him at what he values his opinion in dollars. And I would ask Mr. Paxman "how many dollars will you go that I do not save, as I have offered, at least 25 per cent. of power on the Fisheries installations?" I do not want to hold him to his word as to the princely offer he made me of his engines and boilers, but I do want a fair field and no favour in demonstrating that, by the simple and comparatively inexpensive means I have offered to employ, the electric light at the Fisheries can be saved from the great danger of disastrous collapse that now threatens it.

I address myself to you because the province of your journal is to protect the interests of electricians, and to see that the faults of others are not fathered upon them.—

Yours, &c., M. F. Adams.

London, July 18, 1883.

AN ELECTRICAL STEAM LAUNCH.

On Tuesday an experimental trip was made with a launch built by Messrs. Yarrow and Co., of Poplar, of galvanised steel 40ft. in length, and propelled by a Siemens dynamo placed at the stern under the floor, which drives a screw propeller direct. The electricity for giving motion to the dynamo is obtained from Faure-Sellon-Volckmar accumulators placed under the floor of the boat, so that they are quite invisible, and occupy no space that would be available for passenger accommodation. In this respect the electrical system will be seen to have a very great advantage over steam, as in a launch of these dimensions at least 11ft. of the central and best part of the boat would be occupied by the boiler and engines. Consequently, in comparing launches propelled by steam or electricity, it must be borne in mind that the passenger-carrying accommodation for the same dimensions is much greater in the electrically-propelled boat. The run from the Temple Pier to Greenwich was made in thirty-seven minutes with a moderate tide. The distance is six miles, so that, making allowance for the tide, it may be said that a speed of over seven miles an hour was attained, and full power was not employed save for a portion of the time. On the measured mile an average speed of over eight miles an hour has been obtained.

The boat had twenty-one persons on board, including the steersman and a man to look after the machinery, if such it may be called. Eighty cells of Sellon-Volckmar accumulators are used, of which fourteen are disposed under the seats, seven at each side, and the remainder in the bottom of the boat under the floor. The thrust block is just aft of the dynamo, which is placed under the floor in the stern sheets. It lies flat, and occupies very little space. There are four brushes, two for going ahead, two for going astern, and two small lines going to a becket beside the steersman enable him at a moment's notice, by pulling one or the other, to go ahead or astern; a cylindrical switch beside him enables him to stop or go on at pleasure. This switch is graduated so that the current from forty, sixty, or eighty cells can be used at pleasure. The weight of the whole—batteries and dynamo—is about two tons, or as nearly as possible that of engine, boiler with water, and coal for a steam engine competent to propel her at the same speed.

This pretty launch is the very perfection of a pleasure boat; no heat, no smoke, no dust, no steam, no smell of oil, no splashing of pumps. There is no noise of any kind to be heard save the bubbling of the water from the propeller, and the faint hiss caused by the commutator rubbing against the brushes. There is no smell, and there are no furnaces; and the boat will run for six hours continuously, or about forty miles.

During the trip to which we are referring the current passed through the dynamo was 41·22 amperes from sixty cells, the electromotive force being 112·5 volts, and $\frac{41{\cdot}22 \times 112{\cdot}5}{746}$ = 6·21 horse-power. The loss by friction, &c., must be very small, for 6 indicated horse-power could certainly not have propelled the boat at the speed she really attained. It has long been known that the screw is an extremely wasteful propeller. It may yet be that further investigations will show that the screw is not so much to blame as the combination of screw and engines. At any rate the system of electrical propulsion opens up a new field of inquiry, because it renders possible the use of screws of extremely fine pitch revolving at a great speed. The dynamo in Mr. Yarrow's boat makes about 680 revolutions per minute. The propeller is of steel, two bladed, 19in. diameter, and 13in. pitch. There is absolutely no vibration, and very little disturbance of the water in the wake of the boat.

For such work as that now done by steam launches on the Thames, the electrical system is simply perfection. The expense will be, on the whole, about that of steam, but to those who keep steam launches expense is a secondary consideration, and it must not be forgotten that a 20ft. electrical launch will afford at least as much accommodation as a 30ft. steam launch. Little difficulty should be encountered in charging the cells, and this is merely a question of detail.

After the cells are once stored with electricity they will remain so for a considerable time, subject only to a diminution through leakage; consequently a boat once charged is available for use at a moment's notice, while with a steam launch it is necessary to give one or two hours' notice before hand in order to get up steam.

The Western and Brazilian Telegraph Company.—The traffic receipts for the week ending 13th July were £1,853, after deducting the "fifth" of the gross receipts payable to the London Platino-Brazilian Telegraph Company.

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ELECTRIC LIGHTING (HOLBORN VIADUCT).

The following is Mr. W. Haywood's report to the Streets Committee of the Commissioners of Sewers:—"The experimental electric lighting of the Holborn-viaduct with Edison's incandescent lamps having been in operation for a period of twelve months on the 24th April last, I have to report the general facts relating to the experiment. On the 29th October, 1881, application was made by the Edison Electric Light Company for permission to light the public ways of the Holborn-viaduct with Edison's incandescent lamps. Permission was granted by the commission, and an agreement entered into on the 2nd January, 1882, Mr. Johnson, the manager, undertaking on the part of the company to light the viaduct for three months, between the 1st February and the 30th April, 1882, free of cost to the commission. At the time this agreement was entered into it was understood that the Edison Company would not be interfered with by the commission if they introduced their system of incandescent lighting into the premises upon the viaduct, although the commission gave, and could give, no authority for this being done. Owing to various circumstances the lighting of the viaduct was not commenced until the 24th April, 1882. It was then in thorough working order, and the ordinary gas lighting was dispensed with. The lighting having been in operation for a period of three months on the 24th July, 1882, the Edison Company applied to the commission to have the experiment extended for a further period of six months from the date named, upon the commission paying the same amount for electric lighting they would have had to pay for the ordinary gas lighting during that period. This was agreed to, and the lighting was continued until the 24th January of the present year. Subsequently it was agreed that the contract should be extended for a further term of twelve months from the 24th January of the present year, upon similar conditions, that is to say, at the price of the ordinary gas lighting, the commission reserving to itself the right of determining the contract upon its giving ninety days' notice of its intention to do so. The viaduct is now lighted on these conditions. The viaduct had, therefore, been lighted by the Edison Company for a period of twelve months on 24th April last. It is to that period my report applies, and following the course adopted in previous reports on the various systems of electric lighting in the City, I now give some details of the incandescent lighting. The machinery for generating the electric current is fitted up in the basement of No. 57 on the Holborn-viaduct, the premises are on the northern side of the way, between Farringdon-street Bridge and the Snow-hill Station of the London, Chatham, and Dover Railway. The company has also used other premises in the rear of No. 35, Snow-hill for the purpose of the experiment. The machinery for generating the electric current is of a novel character, and is stated to have been specially designed by Mr. Edison. There are two of Edison's dynamo machines, each worked by a Porter-Allen direct driving engine capable of working to 140 horse-power indicated. One dynamo can sustain 1,000 lamps, the other 1,200 lamps of 16 candle-power each. In addition to the two, a third 1,200 light dynamo, fitted with a similar engine, has been erected in the company's premises at the rear of No 35, Snow-hill; this is now at work. A 250 light dynamo, driven by an Armington and Sims engine, has also been placed in position, and is being used for supplying electrical current to such consumers as may require light during the daytime. All these particulars are supplied me by the Edison Company. From the dynamos the conductors were laid direct into the subways beneath the viaduct, an opening having been made from the house vault of No. 57 into the subway for that purpose. The main conductors are formed of solid copper rods, semicircular in section, embedded in an insulating material and enclosed in wrought-iron pipes; these are laid upon the brackets in the subways, provided there for similar purposes when the subways were built. From the main conductors the connections with the public lamps and with private premises were made by means of insulated cables and wires. Where the conductors pass beneath the Farringdon-street and Shoe-lane bridges, they are suspended from the girders. Owing to the contiguity of the house vaults to the subways which exist beneath the footways on each side of the Holborn-viaduct, the main conductors and the various connections with the lamps and premises upon the line of the viaduct were made without disturbing the surface of the public ways. In fact, it has not been found necessary to make any opening upon the surface of the viaduct for the purpose of the experiment. The electric lamps used are those known as Edison's incandescent lamps, and consist of pear-shaped glass globes containing thin loops or filaments of carbon in vacuo, heated to a state of incandescence when the electric current is passed through them. The number of incandescent lamps in use for lighting the public way when the experiment first commenced was 176—of which 156 were each of 16 candle-power, and 20 each of 8 candle-power—two 16 candle-power lamps were placed in the majority of the ordinary gas lanterns, and several groups of eight 8-candle lamps were placed in the lanterns at other places. This arrangement was modified towards the end of August last, the two incandescent lamps in each gas lantern were removed, and one lamp (said to be equal to about 16 candles) was placed in each of the ordinary gas lanterns. The lamps on the five-light column at the eastern end of the viaduct, and on that at the junction of the viaduct and Snow-hill, were also removed, and large lanterns, octagonal on plan, each enclosing eight incandescent lamps, were placed in them. Each incandescent lamp is said to have been equal to 16 candle-power. These lanterns were fitted with reflectors for throwing down the light on to the public way. On the four public staircases leading from the viaduct to Farringdon-street the incandescent lamps were not enclosed in the ordinary gas lanterns, but were suspended outside the lamps. Each had 16 candle-power. With the exception of those on the five-light columns referred to, the existing lanterns and posts were utilised for fixing the incandescent lamps. The gas fittings were not removed; the incandescent lamps were made movable, the connecting wires being taken from the subways through the bases of the lamps to the lanterns in lengths of gas tubing. This arrangement enabled the incandescent lamps to be removed, and the gas to be immediately lighted in the event of a failure in the electric light. The total number of incandescent lamps in use during the latter part of the experiment, or, as it may be said, when the experiment was in complete operation, and as at the present time, is as follows:—

	Lamps of 16 c.-p. each.
In the ordinary gas lamps on the viaduct and those around the Prince Consort's Memorial.........	64
On the five-light column at the eastern end of the viaduct and at Snow Hill	16
On the staircase buildings............	12
Total............................ ..	—92

[I am informed by the company that the total number of incandescent lamps on the line of the viaduct, in use in private premises, and maintained from their works, is about 745.] The total length of thoroughfare lighted is about 466 yards, and the superficial area about 12,400 yards; each incandescent lamp upon the viaduct illuminates an area of about 155 yards superficial. The illuminating power of each of the incandescent lamps in use since August is stated by the company to be about 16 candles. No photometrical observations to test the accuracy of this statement have been made by the officers of the commission. The number of gas lamps disused while this experiment has been in operation is 86. Each of these is fitted with a batswing burner, consuming five cubic feet of gas per hour, the illuminating power of which is customarily estimated at about 14 candles each. The relative illuminating power of the Edison incandescent lamps and of the gas lamps is therefore as follows:—

	Candles.
92 incandescent lamps, say at 16 candles each........................	= 1,472
86 ordinary gas lamps, at 14 candles each........................	= 1,204

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The illuminating power of the incandescent lamps is therefore about 1·22, or say $1\frac{1}{4}$ times as much as that of the ordinary gas lamps. The cost of the gas lighting on the viaduct at the present contract price to the commission would be £388 8s. 8d. per annum, and the Edison Company light the viaduct for that price. This is at the rate of £4 10s. 4d. per lamp per annum. Thus the illuminating power of the electric light is about $1\frac{1}{4}$ times that of the ordinary gas lighting, and at the same cost as gas lighting. As at other places when experiments in lighting have been in operation in the City of London, arrangements were made with the police for carefully noting defects. Reports were furnished to me daily by Colonel Fraser, giving the situations of the defective lamps, and the time the defects existed. These were sent to the Edison Company, who returned them to me with such explanations or remarks as they thought necessary to make as to the cause of the failure in the lighting. Considering it essential for the commission to have before it a complete account of these defects, a list of them is given in the Appendix. The extent and nature of these failures may briefly be stated as follows:—There were for the first portion of the experiment, until the end of August last, 176 incandescent lamps in operation, that is two lamps in the majority of the 86 gas lanterns, and several groups of eight lamps, each assumed to be alight 1,052 hours from the 24th April to that date, which is equivalent to 185,152 hours lighting of a single lamp. There were 92 incandescent lamps in operation for the remainder of the twelve months, each assumed to be alight 3,228 hours, which is equivalent to 296,976 hours lighting of a single lamp. These together are equal to a total of 482,128 hours lighting of a single lamp. The total number of failures in the lighting from all causes was 815, counting every failure each night separately; their aggregate duration was equal to 1,515 hours of a single lamp, or about ·03 per cent. of the entire lighting for the twelve months. It may be said broadly that a defect of longer or shorter duration occurred in something like 1·17 lamps nightly out of the 176 lamps lighted in the first portion of the year, and 2·80 lamps nightly out of the 92 lamps lighted during the remainder of the year. The principal failures appear to have arisen from defects in the machinery, and many from defective carbons in the incandescent lamps. This was the first experiment in the metropolis in lighting a public thoroughfare with incandescent lamps, all previous experiments having been made with arc lamps of large illuminating power placed at considerable intervals apart. The arc system may be suitable for lighting large open spaces, and from the intensity of its light, which dazzles the eye, it receives a large amount of public attention. But the perfection of public lighting consists in the equal distribution of light over the surface of the streets, and this the arc light does not accomplish. If the arc lights be reduced in power, their number increased, and the distance between them diminished, the objection to them would of course be less, but, unless this be done, it is not so good a mode of lighting the public ways as either gas light or the incandescent light. The Holborn-viaduct is a favourable situation for the trial of incandescent lights, it being a thoroughfare of regular width, and on which the gas lamps are placed at regular intervals apart, no lamp being more than 60 feet from the next one, and the diffusion of light, whether gas or the incandescent light be employed, provided that all the lamps are lighted, is better and more uniform than in most of the thoroughfares of irregular width in the City. It should be mentioned with respect to this incandescent lighting, that it has been subject to a somewhat unfortunate comparison with the gas lighting next to it; for whilst it has been in operation, the whole length of that portion of Holborn which is within the City, and is to the west of the viaduct, has been lighted with Siemens's regenerative gas burners, and the large five-light lamp column at the western end of Newgate-street has also been lighted with a similar burner; the lamps in Holborn are almost as close together as the lamps on the Holborn-viaduct, and have each a nominal light of 130 candles, whilst that in Newgate-street had a light of 400 candles. These Siemens lamps, which cost about £17 5s. per annum to light and maintain, have been naturally put into comparison with the Edison incandescent lamps costing but £4 10s. 4d. per annum to light and maintain. The contrast between gas lamps of 130 candle-power and incandescent lights of 16 candle-power has been necessarily greatly to the detriment of the incandescent lamps, and this has been much remarked upon by persons unacquainted with the facts. The Siemens lamps have just been removed; a comparison with ordinary gas lamps will now be afforded, and conclusions as to the value of the Edison incandescent light, compared with the ordinary gas lighting of the City, can now be more correctly arrived at."

ON THE CHEMICAL CORROSION OF CATHODES.*

BY G. GORE, LL.D., F.R.S.

(CONCLUDED FROM PAGE 215.)

Experiment 10.—A trial was made to find whether two plates of pure silver cut from contiguous parts of the same piece, and then carefully cleaned by rubbing with a rag dipped in potassic cyanide solution, and immersing first in cold and then in boiling distilled water, and drying, were corroded at the same rate. The corroding solution consisted of 50 grains of potassic cyanide (sample "b") in each ounce of water. The plates were immersed in precisely similar positions during four hours at atmospheric temperature.

Plate A lost	·391 =	·0977	grain per hour.
Plate B lost............	·389 =	·0972	" "
Difference	·002 =	·0005	" "
After two hours' further action			
Plate A lost	·296 =	·1480	grain per hour.
Plate B lost............	·271 =	·1355	" "
Difference	·025 =	·0125	" "
After another two hours			
Plate A lost	·248 =	·1240	grain per hour.
Plate B lost............	·253 =	·1265	" "
Difference	·005 =	·0025	" "

Remarks.—These results again show the difficulty of obtaining plates which are equally corroded.

The presence in the liquid, even in minute amount, of certain kinds of dissolved impurities, would distinctly affect the rate of corrosion; if the liquid contained only a mere trace of a salt of a more negative metal than that of the cathode it would be deposited upon the cathode, and thus form a voltaic pair, and increase the corrosion. Even with two pieces of the purest metal, immersed in the purest liquid, kept at the same temperature during the same length of time, and under apparently the same conditions in every respect, the same rates of corrosion could not be repeatedly obtained.

The altered chemical composition of the liquid around the cathode also, caused by substances set free or formed by electrolysis, affected the corrosion.

COMPOSITION OF THE LIQUID AROUND THE CATHODE.

Experiment 11.—In order to ascertain whether the protective effect of the current upon a silver cathode in a solution of potassic cyanide was due to some immediate influence of the current, or to the chemical effect of substances liberated or produced by electrolysis, four ounces of a solution containing 300 grains of potassic cyanide (sample "a") was put into a large U-shaped glass tube, and $1\frac{1}{2}$ ounce of the same liquid into a glass cup of the same diameter. An electric current from four Smee cells was passed, during nineteen hours, through the liquid in the tube by means of a sheet-iron anode and platinum cathode immersed about $2\frac{3}{4}$ inches. Gas was somewhat freely evolved at the cathode. The current was then stopped and the electrodes removed. Three perfectly similar plates of silver, one inch wide, were now suspended $2\frac{3}{8}$ inches deep in the three portions of liquid respectively of the two vessels, during several successive

* From the *Proceedings of the Birmingham Philosophical Society.*

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periods of time, and weighed at the end of each period, no electric current being now employed. The losses were as follow:—

Hours.	In the Anode Liquid.		In the Cathode Liquid.		In the Comparison Liquid.	
	Loss.	Loss per hour.	Loss.	Loss per hour.	Loss	Loss per hour.
2	·158	·0790	·131	·0655	·170	·0850
2	·106	·0530	·155	·0775	·162	·0810
2	·139	·0695	·158	·0790	·178	·0890
15	1·023	·0682	1·101	·0734	1·259	·0839
21 Total.	1·426 Total.	·0674 Average.	1·545 Total.	·0738 Average.	1·769 Total.	·0847 Average.

Remarks and Conclusions.—The average corrosion of the silver in the anode liquid was to that in the comparison one as 79·69 to 100, and the protective effect was, therefore, 20·31 per cent.; whilst that in the cathode liquid* was to that in the comparison one as 87·13 to 100, and the protective effect 12·87 per cent.; or for the first hour alone it was 22·94 per cent.† These numbers show clearly that electrolysis of the liquid produced such an alteration in the chemical composition of the portion of it around the cathode as to largely reduce its subsequent corrosive action upon silver. The protective influence, therefore, of an electric current upon a silver cathode in a solution of potassic cyanide is at least partly due to chemical changes produced in the liquid by electrolysis—*i.e.*, to caustic potash formed at the cathode. In what way the cyanogen liberated and dissolved in the liquid around the anode diminishes the subsequent corrosion of the silver I have not examined. The irregularities in the variations of the numbers were probably in some degree due to changes of temperature. As after making various experiments it was found that an iron anode is slightly corroded in a solution of potassic cyanide, some of the numbers in the above table may be affected by that circumstance, but only to a minute extent.

Experiment 12.—In a similar experiment, $1\frac{1}{4}$ ounce of dilute sulphuric acid, consisting of three volumes of acid to ten of water, was placed in a narrow glass cup, four ounces of the same mixture were electrolysed in the bent glass tube of Experiment 11, by means of sheet platinum electrodes and a current from four Smee cells during $2\frac{1}{2}$ hours. Gas was freely evolved; the current was then stopped, and the electrodes removed. Three similar sheets of electro-copper were suspended in the three separate portions of liquid of the two vessels, and weighed at separate intervals of time. The following were the losses:—

Hours.	In the Anode Liquid.		In the Cathode Liquid.		In the Comparison Liquid.	
	Loss	Loss per hour.	Loss	Loss per hour.	Loss	Loss per hour.
2	·039	·0195	·010	·0050	·043	·0215
16	·102	·0063	·046	·0028	·144	·0090
2	·020	·0100	·012	·0060	·031	·0155
20 Total.	·161 Total.	·0119 Average.	·068 Total.	·0046 Average.	·218 Total.	·0153 Average.

Remarks and Conclusions.—The average corrosion of the copper in the anolyte was to that in the comparison liquid as 77·77 to 100, and the protective effect, therefore, 22·23 per cent., whilst that of the catolyte was 30·06 to 100, and the protective effect 69·94 per cent. As with silver in solution of potassic cyanide (sample "a,"—*see* Experiment 4), so in this liquid the electric current affected the chemical corrosion at *each* electrode, and the corrosion was in each case greater in the non-electrolysed than in either of the previously electrolysed portions of liquid. But in this experiment the subsequent protective effect was three times greater in the catolyte than in the anolyte portion of liquid. But few experiments were made with copper, partly on account of the frequent variations of weight caused by unequal oxidation.

The corrosive influence upon a silver cathode during electrolysis of a cyanide of potassium solution containing caustic potash produced by the electrolysis would probably be greater than that of a liquid of perfectly similar composition, but not undergoing electrolysis, because in the former case the liquid around the cathode would be stirred by the escaping hydrogen, whilst in the latter it would be much less in motion. Another influencing circumstance is, the potash resulting from electrolysis is produced in a layer all over the surface of the cathode, whilst that in the comparison liquid is distributed equally throughout the mass of solution. What the proportion of difference in the two cases is I have not examined.

Experiment 13.—To test in another manner the influence of alkalinity of the liquid upon the corrosion of silver, 300 grains of potassic cyanide (sample "a") were dissolved in six ounces, by measure, of water. The liquid divided into two equal volumes, and $1\frac{1}{2}$ grain of pure potassic hydrate dissolved in one of the portions. Two previously-weighed sheets of silver of the usual dimensions were each immersed $2\frac{3}{8}$ inches deep in the two liquids respectively during fifteen hours.

	Grain.		Grain.	
The sheet in the alkaline liquid lost	·963	or	·0642	per hour.
„ potassic cyanide alone	1·028	„	·0685	„

Proportion of loss, 93·7 to 100 = a protective effect of 6·3 p.c.

4·5 grains more potash were now added to the comparison liquid, and the plates re-immersed during six hours.

	Grain.		Grain.	
The plate in the alkaline liquid lost	·406	or	·0676	per hour.
„ potassic cyanide alone	·422	„	·0703	„

Proportion of loss, 96·2 to 100 = a protective influence of 3·8 per cent.

After a further forty hours of re-immersion

	Grains.		Grain.	
The plate in the alkaline liquid lost	2·332	or	·0583	per hour.
„ potassic cyanide alone	2·174	„	·0543	„

Proportion of loss, 107·2 to 100 = a corrosive influence of 7·2 per cent.

Remarks and Conclusions.—The protective effect in this case was much less than in the stronger solution of potassic cyanide (in Experiment 4), which had been previously electrolysed before immersing the silver. These results support in the main the conclusion that the protection afforded by an electric current entering a silver cathode from a solution of potassic cyanide is partly due to the formation of potassic hydrate by electrolysis at that electrode. But as the presence or addition of caustic potash only diminished the corrosion, whilst the electric current is capable of entirely preventing it, the current operates not only by producing potash at the cathode, but also in some other manner.

Experiment 14.—To further examine the influence of greater alkalinity of the liquid upon the corrosion of silver cathodes, 600 grains of potassic cyanide (sample "a") was dissolved in twelve ounces of water, the solution divided into two equal portions, and sixty grains of pure caustic potash dissolved in one portion. Each of these liquids, A and B, was divided into two equal parts, one of A and one of B being used as electrolytes, with an anode of platinum and cathode of silver, and the others as comparison liquids, with the usual sheets of silver immersed in them. A current from four Smee elements was passed through the two electrolytes arranged in single series during $41\frac{1}{2}$ hours at 52·2deg. Fahr.

In the Solution of Cyanide

	Grains.		Grain.	
The silver cathode lost	1·823	=	·0439	per hour.
„ comparison sheet lost ...	2·896	=	·0697	„

Proportion of loss, 63·25 to 100 = to a protective effect of 36·75 per cent.

* I have sometimes found it convenient to use the term *anolyte* and *catolyte* to designate respectively the portions of liquid which are in contact with and around the anode and cathode.

† The rates of corrosion during the first two hours afford another mode of comparison.

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In the Solution of Cyanide and Potash

	Grain.		Grain.	
The silver cathode lost	2·094	=	·0504	per hour.
„ comparison sheet lost...	2·518	=	·0606	„

Proportion of loss, 83·16 to 100 = a protective effect of 16·84 per cent.

Remarks.—In this case the most alkaline liquid exercised the least protective influence upon the cathode, but greatest upon the comparison plate.

INFLUENCE OF TEMPERATURE.

Experiment 16.—With two pieces of silver in two portions of solution of potassic cyanide containing 25 grains per ounce, the amounts of corrosion at average temperature of 46·0deg. and 57·7deg. Fahr. were respectively ·558 grain and ·629 grain, or ·0757 and ·0798 grain per square inch per hour.

Experiment 17.—To find the influence of difference of temperature upon the rate of corrosion of a cathode, 120 grains of potassic cyanide (of 93·5 per cent.) were dissolved in twelve ounces of water, and the solution divided into four equal portions, two of which were kept at 71deg. Fahr., and the other two at 150deg. Fahr. Four similar sheets of pure silver two inches long and one inch wide were immersed vertically, each to a depth of two inches, in the several portions of liquid during five hours. An undivided current from six Smee cells was passed through the plates of one of the hot and one of the cold portions, the other two immersed plates without a current being used for purposes of comparison.

At 71*deg. Fahr.*

	Grain.		Grain.	
The cathode lost	·021	=	·0042	per hour.
The comparison sheet lost..	·213	=	·0426	„

At 150*deg. Fahr.*

	Grain.		Grain.	
The cathode lost	·016	=	·0032	per hour.
The comparison sheet lost.	·322	=	·0656	„

Remarks.—According to these results a current of equal strength exercised a greater protective power in the hot liquid than in the cold one; the corrosive power, without a current, was, as usual, much the strongest in the liquid of highest temperature.

Experiment 18.—To ascertain the influence of temperature on the corrosion of silver electrodes, and upon the deposition of silver in a solution composed of 180 grains of potassic cyanide (sample "a"), 300 grains of argentic cyanide, 36 grains of free potassic cyanide, and 12 ounces of water, the liquid was divided into four equal portions, two of them being for electrolysis, and two as comparison liquids containing similar sheets of silver. One of the comparison liquids and one of the electrolytes were kept at 63deg. Fahr., and the other two portions at 150deg. Fahr., in a water bath, and the loss by evaporation occasionally corrected by addition of water. The undivided electric current was from two Smee elements, and was continued during four hours.

At 63*deg. Fahr.*

	Grains.		Grains.	
The silver anode lost	19·779	=	4·9447	per hour.
„ cathode gained	19·253	=	4·8132	„
Difference	·526 grain.			
„ comparison sheet lost.	·239	=	·0597	„

At 150*deg. Fahr.*

	Grains.		Grains.	
The silver anode lost..............	20·539	=	5·1347	per hour.
„ cathode gained	19·228	=	4·8070	„
Difference	1·311 grain.			
„ comparison sheet lost.	·423	=	·1057	„

Remarks.—I have shown elsewhere ("The Electrolytic Balance of Chemical Corrosion,") that when a current is passing into a silver cathode from a solution of potassic cyanide containing a very small amount of argentic cyanide, and the density (or strength per unit of surface) of the current is gradually increased, the rate of corrosion of the cathode gradually diminishes until (simultaneously with the commencing deposition of silver) it entirely ceases. In such a case, during the period that the amount of current passing is small, the whole of it traverses the cyanide of potassium, and no silver is deposited, but immediately that the amount becomes too large to be wholly conveyed by that salt, a portion traverses the salt of silver also, and deposition of that metal commences. By increasing still further the strength of the current, a large amount traverses the silver salt, and the rate of deposition of silver increases, but approximately the same amount of current appears to still traverse the free cyanide of potassium. The results in the present experiment show that if now the temperature be raised the same relative proportions of current pass through the silver salt and free cyanide of potassium as in the cold solution. They are, therefore, consistent with the inference that no corrosion, nor any difference of corrosion, of the cathode was produced by rise of temperature.

INFLUENCE OF STRENGTH OF CURRENT.

Experiment 19.—The influence of difference of strength of two currents of equal electromotive force was now tried. A current from three elements of zinc and platinum in dilute sulphuric acid was divided and passed through the coils of a differential galvanometer, and through two portions of a solution containing 100 grains of cyanide of potassium (of 86·65 per cent.) per ounce of water, and ·271 grain of silver dissolved in the solution of each glass, with anodes of sheet platinum and cathodes of sheet silver. Wire resistance was inserted in one of the circuits, and any variation of the currents indicated by the galvanometer. The currents were also passed through two argento-cyanide of potassium solutions in order to measure their amounts. After six hours' action at 54·5deg. Fahr.,

In the Circuit of the Greater Current

	Grain.		Grain.	
The silver cathode in the corroding solution had gained	·110	=	·0183	per hour.
The one in the depositing solution had gained	1·618	=	·2693	„
The silver anode in the depositing solution had lost	1·992	=	·332	„

In the Circuit of the Lesser Current

	Grain.		Grain.	
The silver cathode in the corroding solution had lost	·075	=	·0125	per hour.
The one in the depositing solution had gained	·160	=	·0266	„
The silver anode in the depositing solution had lost.....................	·572	=	·0953	„
The silver comparison plate in the corroding solution had lost	·599	=	·0998	„

Remarks.—The greatest current exercised the most protective power. Gas was evolved freely from the cathode with the stronger current, and less freely from that with the lesser current.

A large number of experiments were made expressly to test the question whether difference of electromotive force alone, independently of difference of strength of current, affected the rate of corrosion; but the difficulties of ensuring perfect uniformity in all the other conditions which affected the corrosion were so great that sufficiently decisive results were not obtained.

THE COST OF ELECTRIC LIGHTING AS COMPARED WITH GAS.*

Eight years ago the electric light was only used for scenic effects in theatres, or for dissolving views, but not for ordinary illumination. Since that time, the number of systems for producing the electric light has become so great that it is impossible to mention all. The present paper will, therefore, only deal with those systems that have come more prominently into notice, viz.:—In Belgium, the Serrin, Jaspar,

* Abstract of a paper read before the Liege Association of Engineers, by Mons. J. Dumont, railway engineer to the Belgian Government.

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Siemens, Jablochkoff, Soleil, Edison, Maxim, Swan, and Brush systems; in France, the Serrin, Jablochkoff, Werdermann, Reynier, De Meritens, Lontin, Gérard, Jamin, Soleil, Gramme, and Brush; in Germany, the Siemens and Jablochkoff; in England, the Brush, Jablochkoff, Siemens, Brockie, Crompton, Soleil, Swan, and Lane-Fox; in the United States, the Brush, Weston, Jaël, Edison, and Maxim; in Russia, the Jablochkoff and Siemens; and, in Holland, the Jablochkoff, Jaspar, and Siemens. To obtain a general idea of the electric light from an economical point of view, I will first establish the cost, based upon the yield of light per horse power, irrespective of any particular system, and then the actual cost of various installations on different systems, calling the former "general prices," and the latter "actual prices."

General Prices.

In the following observations, the unit of luminosity will be taken as that produced by a Carcel lamp (9·6 standard candles) burning 42 grammes (nearly 1½oz. avoirdupois) of refined colza oil per hour; 7 centimes (nearly ¾d.) as the cost of a horse power produced by steam-engine; and, in comparison with gas, the burner consuming 140 litres (nearly 5 cubic feet) of gas per hour with the intensity of a Carcel flame. In practice, a horse-power is capable of producing 200 Carcel flames with large single-light electric arc lamps; 100 Carcels with medium single-light ditto; 50 Carcels with Jablochkoff "candles" and some forms of regulator; 25 Carcels with incandescent lamps *in pleno;* and 10 Carcels with some incandescent lamps *in vacuo*. The cost per hour in carbons for electric lamps may be put as follows:—

15c. (1½d.)	for large lamps of	500	Carcels.
18c. (1¾d.)	„ medium „	250	„
10c. (1d.)	„ small „	150	„
15c. (1½d.)	„ Jablochkoff candles of	50	„
6c. (½d.)	„ Werdermann lamps of	25	„

The cost of fittings amounts to 2,000f. (£80) for a large lamp, 1,800f. (£72) for a medium lamp, 1,000f. (£40) for a small lamp, 500f. (£20) for a lamp of from 25 to 50 Carcels, and 60f. (48s.) for an incandescent lamp *in vacuo*. By means of the above data, the cost price of illumination by the electric lamps of various intensities may be arrived at, with the supposition of the following durations of lighting:—600 hours yearly for installations where illumination is only required for certain periods of the year; 1,500 hours for house lighting; and 4,000 hours for cases in which the illumination extends over at least 10 hours a day:—

1.—*Cost of Lighting per Hour with Lamps of* 500 *Carcels.*

	Period of Illumination.		
	600 hrs.	1,500 hrs.	4,000 hrs.
	Cents.	Cents.	Cents.
Motor—3 horse-power, at 7c.	21·0	21·0	21·0
Carbons	15·0	15·0	15·0
Interest on capital and depreciation of installation (2,000f.=£80), at 12 per cent. per annum	40·0	13·3	6·0
Totals	76·0	49·3	42·0

2. *Cost of Lighting per Hour with Lamps of* 250 *Carcels.*

	Cents.	Cents.	Cents.
Motor—2½ horse-power, at 7c.	17·5	17·5	17·5
Carbons	18·0	18·0	18·0
Interest, &c., on 1,800f. (£72), at 12 per cent. per annum	35·0	14·4	5·4
Totals	70·5	49·9	40·9

3. *Do., with Lamps of* 150 *Carcels.*

	Cents.	Cents.	Cents.
Motor—1½ horse-power at 7c.	10·5	10·5	10·5
Carbons	10·0	10·0	10·0
Interest, &c., on 1,000f. (£40), at 12 per cent. per annum	20·0	8·0	3·0
Totals	40·5	28·5	23·5

4. *Do., with Lamps of* 50 *Carcels.*

	Cents.	Cents.	Cents.
Motor—1 horse-power, at 7c.	7·0	7·0	7·0
Carbons	15·0	15·0	15·0
Interest, &c., on 500f. (£20) at 12 per cent per annum	10·0	4·0	1·5
Totals	32·0	26·0	23·5

5. *Do., with Lamps of* 25 *Carcels.*

	Cents.	Cents.	Cents.
Motor—1 horse-power, at 7c.	7·0	7·0	7·0
Carbons	6·0	6·0	6·0
Interest, &c., on 500f. (£20), at 12 per cent. per annum	10·0	4·0	1·5
Totals	23·0	17·0	14·5

6. *Do., with Incandescent Lamps of* 1 *Carcel.*

	Cents.	Cents.	Cents.
Motor—0·1 horse-power, at 7c.	0·7	0·7	0·7
Carbons (if lamps cost 5f. = 4s., and last 1,000 hours)	0·5	0·5	0·5
Interest, &c., on 60f. (48s.), at 12 per cent. per annum	1·2	0·4	0·18
Totals	2·4	1·6	1·38

The prices thus established are for—(1) illumination from a great distance, with Serren, Siemens, or Brush regulators; (2) with Jasper or Siemens regulators; (4) with Jablochkoff candles; and (5) with Werdermann incandescent lamps.

On the other hand, the cost of laying down gas in works is, on an average, 30f. (24s.) per burner, consuming 140 litres (nearly 5 cubic feet) of gas per hour, and giving the light of 1 Carcel flame. Therefore, the light of a gas-burner costs per hour the following prices, according to the charge, whether 30c. (3d.) or 15c. (1½d.) per cubic metre (35·3 cubic feet); that is to say, 7s. or 3s. 6d. per 1,000 cubic feet:—

	Period of Illumination.		
	600 hrs.	1,500 hrs.	4,000 hrs.
	Cents.	Cents.	Cents.
Gas burned, 140 litres per hour, at 30c. per cubic metre	4·2	4·2	4·2
Interest and depreciation on 30f. (24s.), at 12 per cent. per annum	0·6	0·2	0·1
Totals	4·8	4·4	4·3
Gas burned, 140 litres per hour at 15c. per cubic metre	2·1	2·1	2·1
Interest and depreciation on 30f. (24s.), at 12 per cent. per annum	0·6	0·2	0·1
Totals	2·7	2·3	2·2

By means of these comparative cost prices for electric and gas lighting, the following table has been compiled, in which the prices are reduced to the Carcel flame (9·6 standard candles) taken as the unit of luminous intensity:—

	Cost per Carcel per Hour.		
	600 hrs.	1,500 hrs.	4,000 hrs.
	Cents.	Cents.	Cents.
1. Gas burner, yielding a flame equal to 1 Carcel, and consuming 140 litres per hour, at 30c. per cubic metre	4·80	4·40	4·29
2. Similar gas burner with gas at 15c. per cubic metre	2·70	2·30	2·20
3. Electric lamps of 500 Carcel units	0·15	0·10	0·08
4. Electric lamps of 250 Carcel units	0·28	0·19	0·16
5. Electric lamps of 150 Carcel units	0·27	0·19	0·16

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	Cost per Carcel per Hour.		
	600 hrs.	1,500 hrs.	4,000 hrs.
	Cents.	Cents.	Cents.
6. Electric lamps of 50 Carcel units	0·64	0·52	0·47
7. Electric lamps of 25 Carcel units	0·92	0·98	0·58
8. Electric lamps of 1 Carcel unit (incandescent *in vacuo*)	2·40	1·60	1·38

If the electric light could be usefully distributed in the space to be illuminated, it would in all cases be more economical than gas; but practical experiments show that 20 ordinary gas burners can only be replaced by an electric lamp of 250 Carcels (2,400 candles), by two lamps of 50 Carcels (480 candles), or by four of 25 Carcels (240 candles). In this case, as in all cases where it is adopted, a total illuminating power is obtained which is greater than that yielded by the gas which it has replaced.

ACTUAL PRICES.

Illumination of the Telegraph Office at the Brussels Northern Terminus by the Jaspar System.—This is effected by three Jaspar regulators, which supersede 70 gas-burners, each consuming 140 litres per hour, each regulator having a luminous intensity of 235 Carcels (2,256 candles). The comparative cost of producing the light, calculated for a daily period of four hours, is, therefore, as follows:—

Electric Light.		
Motive power	2f. 84c.	
Carbons	0 56	
Interest and depreciation, at 10 per cent.	0 42	
Total for electric light (Jaspar) ...	3f. 82c.	(3s. 0½d.)
Gas.		
Consumption of 70 burners, at 15c. per cubic metre	1f. 45c.	
Breakage of glasses	0 15	
Interest and depreciation, at 10 per cent.	0 24	
Total for gas	1f. 84c.	(1s. 5½d.)

Whence it follows that the electric Carcel unit costs 0·0054f., and the gas ditto 0·0265f. Be it remarked, however, that the motive power is obtained from a gas-engine, which is dearer than steam.

Illumination of the Telegraph Office at the Brussels Northern Terminus by the Jablochkoff System.—In accordance with an estimate made in 1879, the illumination of the same room would require six Jablochkoff candles of 40 Carcels each, the cost per hour being—

Motive power	2f. 840c.
Carbons	0 900
Interest on capital and depreciation, at 10 per cent. per annum	0 387
Total (Jablochkoff)	4f. 127c.

or 0·017f. per Carcel per hour, compared with 0·0265f. for gas.

Illumination of the Place des Nations, Brussels, by the Jaspar System.—Admitting a daily mean of six hours, the cost is—

Electric Light.	
Motive power	2f. 69c.
Carbons	0 56
Interest and depreciation, at 10 per cent. per annum	0 29
Total (Jaspar)	3f. 54c.
Gas.	
Gas consumed	1f. 02c.
Interest and depreciation, at 10 per cent. per annum	0 19
Total (gas)	1f. 21c.

As the total intensity of the electric light is 705 Carcels, and that of gas about 40, the cost of the Jaspar Carcel is 0·00502f. per hour, and of the gas 0·03f.

(TO BE CONTINUED.)

PRACTICAL TELEPHONY.

(CONTINUED FROM PAGE 191.)

The words four batteries, &c., in the third line from bottom of page 189, July 7th, should read one battery, &c.

SEVEN POINT.—This switch, Fig. 40, is similar to the six point, except that it converts the trembling bell *c* into a single stroke when the switch is in the central position, so as to avoid the possible break of circuit when speaking through the contact breaker in bell *c*.

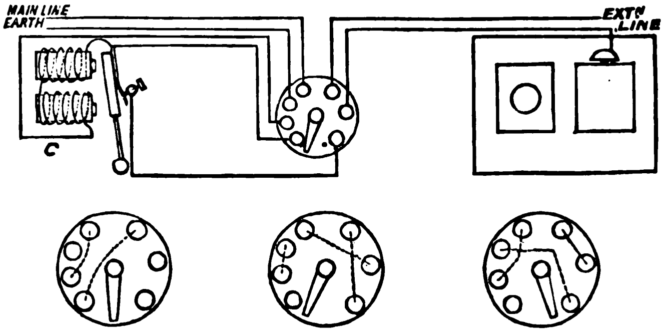

FIG. 40.

In all cases where three or more lines have to be provided with switches, the before mentioned switches would not answer the purpose. It has therefore been necessary to construct what are practically small exchanges, having indicators, &c., varying in number from three upwards. They are also fitted with a bell to call attention. One of these for four lines and the connections are shown in Fig. 41 on next page. The line from instrument consists of a flexible cord fitted with a jack (Fig. 42). This can be pushed under any of the springs under their respective annunciators, taking care that the insulated side is against the earth plate, on which the springs press in their normal position. Communication can then be carried on with that particular line, taking care to close the shutter when done; the jack can be removed or left until another call arrives, which if from another line will, of course, necessitate putting the jack under the spring corresponding to that number. If any two of the lines require to be put through, it is done by means of the double jack cord provided (*i.e.*, a cord with a jack attached to each end), taking the same precaution to put the insulated side against the earth plate and to close the shutters. When the communication is finished it should be indicated by one of the

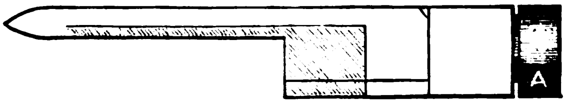

FIG. 42.

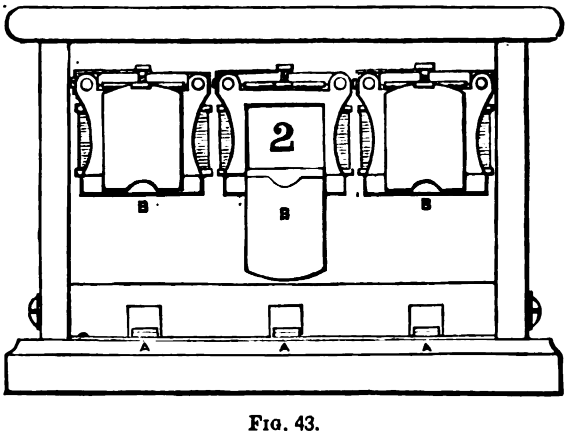

FIG. 43.

speakers pressing his button, which will cause both shutters to fall, which is the signal to disconnect. The cord and jacks must then be withdrawn. The bell is actuated by a single local cell which may, however, form part of the ordinary battery. It is obvious that with any increase in the number of lines it is only necessary to increase the number of the annunciators and springs. Figs. 43 and 44 show the front and back view of a

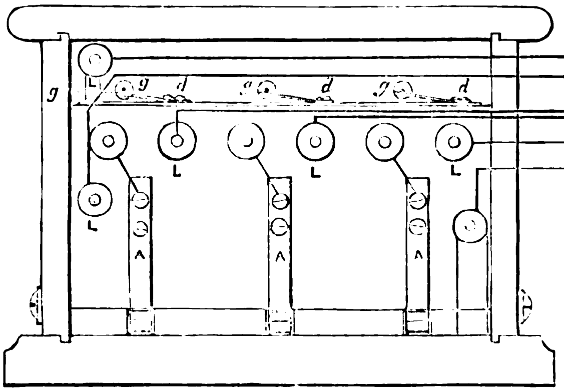

FIG. 44.

three-drop annunciator. A A A slipper springs, B B B annunciators, *g g g*, *d d d* local bell contact, L L L line terminals. The terminals at the left hand are for the local bell, and should be marked B B, and not L L.

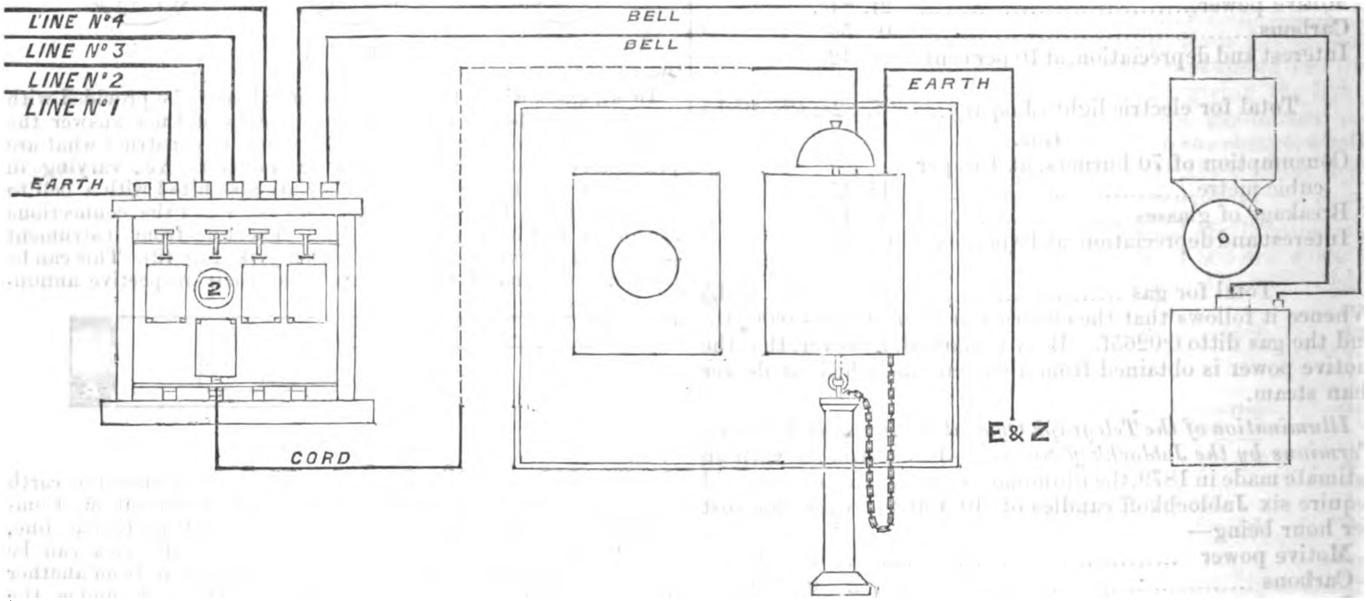

FIG. 41.

RELAYS.—Relays are not much required in telephony. There are instances, however, where they may be employed with advantage. The office of a relay is to close a local circuit (which may consist of a battery and bell, or any other apparatus) when actuated by a line current circulating through its coils. In adjusting single current relays the following points must be observed. The particular construction of the relay is unimportant. The contact screw must be so adjusted that when the armature is firmly on it there is room for a piece of paper to pass between the poles and the armature. The screw which limits the range or play of the armature must be so adjusted that the armature only fairly leaves the contact screw. The tension of the spring must be only sufficient to bring the armature into contact with the upper stop screw. The contact points between the armature and contact screw must be faced with platinum. Relays are used in the instruments, where three or more are in circuit, to avoid introducing the resistance of the bells into the circuit, and also to prevent them interfering with each other when ringing, from their making and breaking contact at different times. They are also necessary on long lines, where, from the resistance of the line, the arriving current has not strength enough to ring the bell, but quite sufficient to attract the armature and close the local bell circuit.

(TO BE CONTINUED.)

THE EASTERN TELEGRAPH COMPANY (LIMITED).

The twenty-second half-yearly ordinary general meeting of the Eastern Telegraph Company (Limited) was held on Thursday, July 12, 1883, at the City Terminus Hotel, Cannon-street, London, under the presidency of John Pender, Esq., M.P., chairman of the Company.

The notice convening the meeting and the minutes of the previous meeting having been read and confirmed, and the report having been taken as read,

The CHAIRMAN said: Before making my general remarks, I will draw your attention to the figures. The revenue for the six months ended March 31, 1883, amounted to £328,405 against, in the corresponding period of last year, £321,810, being an increase of £6,595. We had exceptionally large receipts for telegrams for Egypt, not only in the half year under review, but also in the previous six months. In order to earn this increased amount of money it was necessary to keep open the communication with Egypt at any cost. I may mention that we expended last year on this exceptional account over £62,000, employing in the service no fewer than six ships. Some of these expenses were charged against the September half year, but many items, though incurred before September, appear only in the present accounts. Everything has now been charged, and the result of the year's working must, we think, be considered satisfactory by the shareholders. The South African Company, of which the Eastern Company hold almost all the shares, paid us the same dividend as last year—namely, 8 per cent. They previously paid 10 per cent., but the reason of the fall from 10 to 8 per cent. has been the cessation of hostilities. Looking at the interests of the Cape, I shall be very sorry if the same causes which enabled us to earn 10 per cent. should again occur [hear, hear], because there is nothing so disastrous to a country as war. Though we may reap an immediate benefit of 1 or 2 per cent. from war, I think that a prosperous country and good trade are likely to be much more beneficial to us. Therefore I should much prefer that we grew from 8 per cent. owing to commercial prosperity, than to the breaking out of any hostilities. The ordinary expenses of the Company were in the half year £87,827, as compared with £75,140 in the corresponding period of last year, or an increase of £12,687. This increase is accounted for as follows:—Working expenses at stations, an increase of £8,863. Since March, 1882, we have opened six new stations—namely, Athens, Karystos, Trieste, Corfu, Port Said, and Tripoli, so that this half year's accounts bear their part of the expenses. In addition to the working expenses we have likewise charged a large proportion of the outfit of these stations for instruments, furniture, &c., against revenue, which might fairly have been charged to capital expenditure. Therefore this £12,000 increase is not of a permanent character, for we have taken a good proportion of it from revenue to establish these offices which might have been placed to capital. I am quite sure that the shareholders will approve that course, as it is not desirable to increase the capital account if we can possibly help it. General expenses in London show an increase of £1,016. This is mainly attributable to stationery, printing, and law charges. With respect to the former we have recently had printed and distributed a large number of tariff books containing numerous engraved maps on steel, showing the different telegraph systems of the principal countries of Europe, India, the far East, South Africa, and our colonies in working connection with Eastern Company's lines. With regard to these books that we have published, they will give a good idea of the extent of the ramifications of this telegraph system. If any one is desirous of possessing a copy we will give t him after the meeting is over, and if there are not sufficient here to supply a copy to all we shall be glad to forward them on receiving applications at the office. I think it will be instructive and will give the shareholders even greater confidence than they have at the present moment in the working of this great system.

The expenses of the foreign agencies show an increase of £594, arising from the additional stations and agencies opened. We have been obliged at Vienna to open an agency. The depreciation of cable stores shows an increase of £135, and maintenance ships' reserve fund an increase of £1,900. This is owing to an additional ship. The ship "Volta," which now comes into the books for depreciation, is the cause of the increase of the amount I have re-

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ferred to in the ships' reserve fund. There is another expense—it is a small one—in regard to the protection of submarine cables. I refer to the conference which was held at Paris on the question. Then there is also another special item this half year which was agreed to at the last meeting, namely, the bonus to the staff, which was suggested and carried unanimously by the meeting, on account of the arduous work which they had to do owing to the Egyptian war. That amounted to about £1,000. Now, I think I have given you a pretty fair idea of our increases and decreases; but I am happy to say that, after all this additional expense, we have carried to reserve fund this year £85,000, as against £75,000, at the same period last year. There is another point which, I daresay, will give satisfaction to the shareholders. I have mentioned that whenever we could see our way to do so, consistently with the best interests of the company, we should be prepared to increase our dividend. The last dividend we paid was at the rate of 5½ per cent. We are now prepared to add by way of bonus an additional ½ per cent., which will make for the past year 6 per cent., and at the same time we carry this large increase of £10,000 to the reserve fund. I think, all things considered, we have shown that the past year has been one that has been largely beneficial to the company. At the last meeting I gave you a sketch, and a very full one, of what had occurred during the Egyptian war—the great sacrifices the Company made in the interest, I would say, of the world—and I suppose I may use that word. At all events, we made great sacrifices, certainly in the interest of the British Government and of those who were conducting the war in Egypt. I repeat now that I believe that that war would not have been as short-lived as it was had it not been for the extraordinary facilities which the Commander-in-Chief had through the telegraph, enabling him to keep up his communications with the Admiral and the other branches of the expedition in such a way as to continue the campaign as a compact whole. I believe the telegraph did signal service at the time, and I am glad to say in doing this service I believe it was appreciated to a certain extent. We have not lost by it, and I think the arrangements we were able to make so far justify the large expenditure of £62,000 which we made to give that service. It has given us a very important position not only with the British Government, but also with other Governments. At this very moment another nation—a friendly nation—is engaged in war in the far East. What do they do? They know the benefit we conferred on our own Government by the telegraphic communication we brought to bear in assisting them, and the French Government have therefore come to us, and I believe at the present moment there is a convention signed by that Government which will enable the Eastern Extension Company to carry the telegraph system from Saigon to Tonquin. This is what I should call an additional feeder to our own system, as everything done in that direction brings so much more traffic to the Eastern system.

Now, since I last had the pleasure of addressing you we have made another important addition to our system by laying down a new line—a triplicate line in the Red Sea from Suez to Aden. This had almost become a necessity. At the Cape we had opened up a system, its departing point being Aden. The Government of the Cape considered that they were entitled to a good service, as they were paying us a handsome subsidy. It has been our first consideration always, even before the question of dividend, to make our service so efficient that it would be impossible for any one to make complaints and say to us, "You are not doing this service to our satisfaction, and we must invite others to come forward." There has been some grumbling at the Cape at the rate charged. As you are aware, the Eastern Company are the largest shareholders in the South African system, but we have now shown—and I hope the Cape people will appreciate what we have done—that we desire to meet their wishes. By laying this third cable in the Red Sea it has enabled us to give them such a service as could not possibly be equalled by any other system. That has caused us considerable expense, but looking at the development generally of the East and the far East—a development, which, so far as China is concerned, is but beginning—I regard any expenditure in that direction as likely in the future, and in the very early futuie, to bring very good fruits indeed.

There is one other thing I am pleased to say to-day—that we have not a single ship employed at this moment, and, further, all our cables are in good working order. But it was only yesterday that we got the news of one repair, and the day before the news of another repair. As I have often stated to you, if we could only avoid these repairs we could make very handsome additions to our dividend. We must not crow too much, but still at the present moment we have all our ships in harbour, and the longer they remain there the better.

There is another incident I have to allude to. We are in favour of duplication—I may almost say of triplication. We made an arrangement with the Suez Canal Company for the construction of a land line from Port Said to Suez. We had that line opened, I think, on the 28th of June, and I believe it was only opened about twenty-four hours when our land line through Egypt, on which we were entirely dependent, was run into by a railway train, and the traffic was suspended for some days on that line. Fortunately, however, having secured the line along the Canal, there was no interruption to our traffic. That is a very important incident as showing the value of a duplicate system. The loss to us would have been very serious if the whole of our traffic to India and the far East had been interrupted; but the fact that this line along the Canal was completed just in the nick of time saved us a very serious loss. This question of the Suez Canal, as well as the success of it, has been, as you are all aware, very much before the public of late. I think we, the Eastern Telegraph Company, may claim to be a very important factor in the great success which has attended the Suez Canal. In olden times ships very often carried their own letters; at all events, letters were carried by steam. The ships had to wait sometimes one month, sometimes six weeks, and sometimes longer for cargoes; but now a ship sails, telegraphic communication is made to the point of destination of the ship, and arrangements are made for the cargo. The ship arrives there, is reloaded, and back she goes to England, and that is all done through submarine telegraphy. The submarine telegraph is almost the beginning of every operation that takes place in the East, and I may say almost the end of the operation. Consequently it is one of the most important factors in commercial life at the present moment.

Now, gentlemen, I think I have pretty well given you the different points of interest, and I need not detain you longer excepting with regard to the financial question. I think it will be in the recollection of many within this room that I mentioned we were going to issue debenture stock, the object being to take up and pay off the existing debenture stock, and replace it with debenture stock at a lower rate of interest. This we have resolved to do, and you have had before you a circular to that effect. I think it is not necessary for me to say much in favour of this stock. For a long time at these meetings I have said that submarine telegraphy was a very speculative system; that we placed the cable in the bottom of the sea, and therefore that it was difficult to realise what age that cable would live to. But our experience year after year has satisfied us that the submarine telegraph is about as good a property as a railway property. We know where a break occurs, and can pick the cable up; consequently, every year satisfies us that it is not an uncertain property. As to how long a cable may live, that is a question I cannot answer; but this I can say, that if you take up a cable, the core of it, the real heart, the part that transmits the thought, is as good as the day the cable was laid down, and we have now an experience in these cables of something like fifteen years.

Sir JAMES ANDERSON: Seventeen years.

The CHAIRMAN: Seventeen years; consequently, I have no hesitation now in recommending our debenture stock as a sound and good investment. The prospectus in which we invite the public to subscribe has only been published a very short time; and, looking at the other appeals for money, or rather the other invitations to subscribe capital, I do not see anything before the public at the present moment as good or as safe as this debenture stock of the Eastern Telegraph Company. We have got already applications for a considerable amount of the stock. It will pay about 4¼ per cent. By the money we shall thus receive we shall pay off our present debentures, and we shall pay for this new cable and other things connected with capital. I look for a considerable saving from this reconstruction of our debenture debt. With these remarks I beg to move:—"That the printed report and accounts of the directors to 31st March, 1883, submitted to this meeting, be and they are hereby received and adopted; that a dividend on the Preference shares of the Company to the 30th June, 1883, at the rate of 6 per cent. per annum be paid, less income tax; and that, in accordance with the directors' recommendation, a dividend be and is now declared of 2s. 6d. per share, with a bonus of 1s. per share, both free of income tax on the ordinary shares of the Company, making, with the previous payments by way of dividends on account, a total payment of 6 per cent. on those shares for the year ended 31st March, 1883."

The VICE-CHAIRMAN (the Marquis of Tweeddale): I beg to second that.

Mr. FISHER: Are not debenture stocks generally founded upon some tangible security? In a railway there is the rolling stock, besides the rails and other things that you can get at; but where is the security for a thing at the bottom of the sea?

Mr. HURST: I think the security is as valuable as any railway security, or any other stock. We have an extensive business, and the cables have been working exceedingly well for a long time past. We have been going on from year to year rather improving our prospects, and if there is no security for our debenture stock I am sure that there is no security for anything in existence. You talk of the 3 per cent. consols, there is no tangible security there [laughter], but at the same time it is so sound that property is regarded as secure if it is in the consols. In the same manner, the property of the Eastern Telegraph Company is certainly a security, and a very ample security for this debenture stock. Therefore I think the debentures will very soon be taken up, and people who wish to invest in a good security will be very apt and very happy to take it up. With regard to properties generally, if a man goes to invest money, generally speaking he has an immense difficulty in being quite certain that the security's sound, but here I think you have something far more solid than you would find in almost any other company in existence. We must thank the directors for the manner in which they have conducted this business. They have taken care always to supply the wants of the public. The consequence has been that year after year our property has been improving, and therefore I think there is no doubt about the security offered by this debenture stock; and, in fact, any man who wishes to lay out his money well, and safely, and soundly, cannot do better than take it up.

The CHAIRMAN: The answer I have to give is very short. I have stated to you what we believe the property to be; but when I tell you that we are earning £400,000 a year net, and that the interest on this debenture stock only takes £20,000 of it, you can easily see that it is a very good security. As to its permanency, we also show you from experience that it is as sound as any railway, as we can repair the cables, and we do so, and we always keep up the property in a thorough state of efficiency. I therefore think it is not necessary for me to say anything more about it, but I may add just look at the reserve fund. There we have £569,000 or £570,000, That is a very large sum. You may be perfectly satisfied that the security is a good one, notwithstanding it is lying at the bottom of the sea. [The chairman then put the resolution, and declared it to be carried unanimously.] That, gentlemen, concludes the business of the day.

Mr. JOHN NEWTON: I have much pleasure in rising to move a vote of thanks to the chairman of the Company. I think shareholders in telegraph companies are very greatly indebted to Mr. Pender for what he has done, not only in this Company but in all the others. It has fallen to my lot to criticise the doings of this body of directors, and I must say that what I have done in the past has been productive of some good. But the result has been more beneficial to the shareholders than we could have anticipated some time ago. The very fact that it is possible to place our mortgage debenture stock (for it must not be forgotten that it is mortgage debenture stock) at 4 per cent., or practically so, is evidence of the solid property we now possess. I should not think for a moment of comparing it with consols, as it does not yet bear that comparison; but that it is a very good investment there can be no question. I think it is very greatly due to the capacity, energy, and foresight of the directors that we are in such a position. At the same time the shareholders have not received the advantage which I think they should have received [hear, hear]. Six per cent. is nothing like what was held out on the original formation of the Company. But those who have bought the property at the low prices of some years ago have derived great advantage. I foresaw myself what a great advantage telegraph property would be. I knew it was not possible to conduct the operations of commerce between this country and the East without the use of the telegraph. I have had no doubt of this view for

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twenty years past. That is why I have always taken a great interest in this class of property. I have very great pleasure in moving a vote of thanks to you and to your colleagues for the manner in which you have conducted our business for years past.

A SHAREHOLDER: I second the motion.

The CHAIRMAN: I am very much obliged to you for the way in which you have complimented the Board—my colleagues and myself—for our foresight and energy. It has really been a labour of deep interest this telegraph system. Every day it is expanding, and every day it requires increased attention, and that attention is now valuable from the fact that it is based upon considerable experience. I entirely sympathise with Mr. Newton in his remarks about the dividends, and I entirely sympathise in the expression of approval given to his remarks by the general body of the shareholders present. But just let me tell you the cause. If we had open messages, as we expected they would be when we put this system first before the public, we should have been paying about 60 per cent. to-day instead of 6 per cent.; but such has been the ingenuity of the merchants that this has been prevented. When I tell you that a man spends from £1,000 to £10,000 a year in telegrams, you will see how anxious he is to reduce that amount in every possible way in his power, and the public using the telegraph have shown great ingenuity, and beaten us. I believe in many instances two or three words give as much information as would fill a page of this paper. We cannot contend against them, and we are obliged to accept the position, and this coding system is one that will go on. Still, it is equally remarkable the hold the telegraph has had on the commercial public that we are able to keep up the dividend we are now paying, notwithstanding all this ingenuity. With the present system of telegraphs it would have been impossible to carry the messages had they been all in open language. We must therefore be satisfied with a moderate dividend. I hope, however, that it will grow. If not it will not be the fault of those who sit on this side of the table. I beg to thank you.

The proceedings then terminated.

WEST COAST OF AMERICA TELEGRAPH COMPANY.

The sixth ordinary general meeting of this Company was held on Thursday at the Cannon-street Hotel. Mr. Robinson Kendal in the chair.

Mr. F. S. ROBINSON (the secretary) read the notice convening the meeting, and the report of the directors was taken as read.

The CHAIRMAN said: I have now, gentlemen, to move the adoption of the report and accounts, which are in the hands of all the shareholders, and which you have taken as read. This report is of course not so satisfactory as we could wish, but under all the conditions, which are practically known to every one who either reads the newspapers or is interested in trade, it is perhaps almost as good, if not better than any one expected it to be. For a time we have laboured under serious disadvantages, owing to the continuance of the deplorable war, and the consequent utter stagnation of trade at Lima and other important places in Peru, and it is perhaps in some degree a matter for congratulation that the Company is in the comparatively favourable and progressive condition shown in the report. Up to the 31st December last year the earnings of the Company were £38,908 2s. 10d., against £32,356 15s. 11d. for the previous year, showing a net balance of profit, after paying debenture interest and all charges, of £7,667 11s. 1d., a result which, as the report says, though not altogether satisfactory, is yet far from unpromising. Since the date up to which the report is made out the company has made further progress, and now I am able to confirm what is said in the report—viz., that the mortgage and all other liabilities and arrears of the company, set down at a sum of £20,465 8s. 5d. in the balance sheet for 1881, have been discharged and extinguished. With the discharge of all these arrears and liabilities, incurred through a variety of conditions—the cutting of our cables, the continuance of the war, and the paralysation of trade—the company has assumed a much more favourable position, and the outlook in every sense may be fairly regarded as far from uncheering. Our receipts have continued to increase under all the adverse circumstances under which our operations have had to be carried on, and nothing is required but an assurance of peace and a revival of trade to still further augment our income, and enable us to render to the shareholders an account with which no one will have reason to be dissatisfied. Not that I have either seen or heard any expression of dissatisfaction in regard to the present report, but quite the reverse—everything, in fact, that I have seen or heard being in regard to our accounts, to our economies, and to our working, not only of a satisfactory, but of an agreeable and even complimentary character. In our next report we hope we shall not only show a considerable increase in our income, but a diminution in our expenditure, for the large item for interest will have disappeared—except in regard to a small amount now extinguished—and there will be also various other economies which will tend in a greater or lesser degree, if all things go well, and as we expect, to increase the net profit of the Company's working operations. What the future may bring to us it is not for me to anticipate, but besides the satisfaction of saying that all our past accumulations and indebtednesses are now paid off, I have also the satisfaction of saying that, looking inquiringly into matters, our progress and our prospects are the reverse of discouraging. Our steamer has been overhauled and put into a complete state of repair, as verified by the underwriters' survey and the certificate we have received, and I am pleased to say that through a variety of causes her value to us has been enhanced, so much so, indeed, that we have increased rather than decreased the amount of insurance for which she is covered. The claim of this Company upon the Chilian Government is still in abeyance, but I am not without hope that in a few weeks, or perhaps days, we may hear something of a more definite and satisfactory character. Since the report was issued to the shareholders we have received from our manager on the coast a letter in which he says he hopes either to write us by next mail, or to wire to us, a fresh offer on behalf of the Government for a settlement of a part of our claim, the remainder of the claim being submitted for adjudication to the International Commission now sitting and deciding upon claims arising out of the conflict between Chili and Peru. Whatever the result may be in regard to this claim, I need hardly assure the shareholders that the constant and persistent efforts of the Board have been exerted to bring about a settlement just and honourable alike to this Company and to the Chilian Government. At a time when armies were being decimated, and cities were being sacked, and trade and progress arrested and paralysed, it was, perhaps, too much to expect that the Chilian Government would seriously entertain and settle our claim, but now that matters have assumed a calmer aspect, and peace seems to be in some may assured, as every one hopes, we may reasonably appeal, after so long waiting, to the Chilian Government to do us justice, and in view of the traditions, the honourable traditions, of that Government, we hope we shall not appeal uselessly or in vain.

Mr. MACANDREW seconded the motion.

In reply to a shareholder,

The CHAIRMAN stated that they claimed a very large sum from the Chilian Government, but he would rather not enter into particulars.

The motion was then put and carried unanimously.

The CHAIRMAN said that in view of the encouraging prospects of the Company, and not only the possibility but the probability of their being in a position to form an adequate reserve, and of being able to declare a dividend, he had to move "That the directors of this Company be and are hereby empowered to declare interim dividends out of such profits as may from time to time be available."

Mr. CAMPBELL seconded the motion, which was carried.

Mr. T. F. Campbell and Mr. W. E. MacAndrew, the retiring directors, were re-elected, and Mr. J. Weise (of Turquand, Youngs, and Co.), the retiring auditor, was reappointed.—The proceedings then terminated.

THE DIRECT UNITED STATES CABLE COMPANY.

Report of the directors for the six months ending 30th June, 1883, to be presented at the twelfth ordinary general meeting of the Company, to be held at the Cannon-street Hotel, Cannon-street, on Thursday, the 26th inst., 1883:—With this report the directors submit the usual statements of account for the half year ending June 30, 1883, which, with the half year's accounts to 31st December last, presented at the ordinary general meeting on the 9th February last, show the financial result of the sixth year's working of the Company. The revenue for the half year, after deducting out-payments, amounted to £70,529 19s. 5d. The working and other expenses for the same period, including interest on debentures and income-tax, amounted to £19,315 8s. 9d., leaving a balance of £51,214 10s. 8d. as the net profit of the half year, making, with £1,286 16s. brought forward from the previous half year, a total of £52,501 6s. 8d. Three quarterly interim dividends of 1¼ per cent. each, amounting to £45,532 10s., have been declared and paid at the usual times during the financial year, and a final dividend of 5s. per share is now proposed, making, with the three interim dividends, 5 per cent for the year, being a total distribution of £60,710. The appropriation of the above balance of £52,501 6s. 8d. on the revenue account is thus shown:—Interim dividend for quarter ending 31st March, 1883, £15,177 10s.; final dividend now proposed, £15,177 10s.; carried to reserve fund, thereby increasing it to £315,000, £19,877 17s. 3d.; depreciation of spare cable tank at Halifax, £416 1s. 6d.; carried forward to next account, £1,812 7s. 11d. — £52,501 6s. 8d. The depression in the commercial markets and general slackness of business has had an effect upon Atlantic telegraph cable traffic, the earnings from which show a slight decrease during the past six months compared with the corresponding period in 1881, when the tariff was the same. The establishment of the independent office in New York has given general satisfaction. Pursuant to the provisions of the Articles of Association, two of the directors, viz.:—John Pender, Esq., M.P., and E. M. Underdown, Esq., retire by rotation, and being eligible, offer themselves for re-election. Mr. John G. Griffiths and Mr. John Sawyer, the auditors, retire pursuant to the Articles of Association, and offer themselves for re-election.

COMPANIES' SHARE LIST.

TELEGRAPHS.

COMPANIES.	CLOSING PRICES JULY 18.	BUSINESS DONE WEEK ENDING JULY 18. Highest.	Lowest.
Anglo American	48¼, 49	49⅜	48⅝
Do. Preferred	80½, 80¾	82¼	80
Do. Deferred	18¼, 18¾	18 9-16	18¼
Brazil Submarine	11 11-16, 11 13-16	11⅞	11 11-16
Cuba	10½, 11	—	—
Do. Preference	17½, 18½	—	—
Direct Spanish	5¼, 5¾	—	—
Do. Preference	15½, 16	—	—
Direct United States Cable	12¼, 12¾	12¾	12⅝
Eastern Telegraph x d.	10 13-16, 10 15-16	10 15-16	10¾
Do. 6 per Cent. Preference	12¾, 13¼	12 15-16	—
Do. 5 per Cent. Debentures, 1899	104, 107	—	—
Eastern Extension x d.	11⅝, 11⅞	11⅞	11⅝
German Union	9¾, 10¼	10	9¾
Globe Telegraph and Trust Company	7¼, 7⅝	7½	7 7-16
Do. Preference	12 15-16, 13 1-16	13	12 15-16
Great Northern	12⅝, 12⅞	—	—
Indo-European	32, 33	—	—
Mediterranean Extension	1½, 2	—	—
Do. Preference	5½, 6½	—	—
Reuter's	9½, 10	—	—
Submarine	247, 252	—	—
West India and Panama	1, 1½	—	—
Do. 1st Preference	6½, 7	6½	—
Western Brazilian	5¾, 6¼	6	—
West. Union 7 per Cent. 1st Mortgage	122, 124	124	—
Do. 6 per Cent. Sterling Bonds	103, 106	105	104

TELEPHONES.

COMPANIES.	CLOSING PRICES JULY 18.	Highest.	Lowest.
Consol. Telephone and Maintenance	7-16, 9-16	9-16	½
Oriental	7-16, 9-16	—	—
United Telephone	9⅝, 9⅞	9¾	9¾

ELECTRIC LIGHT.

COMPANIES.	CLOSING PRICES JULY 18.	Highest.	Lowest.
Anglo-American Brush Lgt. (£7 paid)	3⅜, 3⅝	3 9-16	3½
Do. (fully paid)	6, 7	—	—
Hammond Light	2, 2½	2¼	2¼
Swan	1¾, 2¼	2½	1 15-16
Maxim-Weston	⅛, ¼	3-16	—

MISCELLANEOUS.

COMPANIES.	CLOSING PRICES JULY 18.	Highest.	Lowest.
Telegraph Construction	34, 34½	34¼	34
India Rubber, Gutta Percha, and Telegraph Works	30, 31	30¾	—

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NOTES.

SIAM.—Telegraphic communication has now been established with Siam.

ELECTRICAL WORK IN ENGLAND.—Fighting before a Parliamentary Committee.

EARTHQUAKE.—A violent shock of earthquake was felt at Catanzaro, in Calabria, yesterday morning.

KILLED BY LIGHTNING.—On Saturday last at Gobb's Oak, near Cheshunt, a man was killed by lightning while taking shelter under a tree.

VENEZUELA.—The land lines in Venezuela, which have been interrupted more or less during the past five months, are now again in working order.

LOUISVILLE.—The Edison Company is to light the exhibition here. It is stated that 15 dynamos will be used to supply light to 4,500 16 candle-power lamps.

EXETER.—A committee of the Town Council has been formed to report on the best means to be adopted for lighting by electricity the new lunatic asylum.

NEWINGTON.—A stormy vestry meeting was held last week to consider the electric lighting scheme and the Board of Trade inquiry. The meeting, after some disturbance, was adjourned.

SS. "SCOTIA."—The Telegraph Construction and Maintenance Company's steamer "Scotia" had paid out up to noon, 23rd inst., 205 knots of telegraph cable from Vladivostock towards Nagasaki.

YORK.—It is said that the exhibition at York, held during the Royal Agricultural Show week, owes much of its success to the electric light. This work was carried out by Messrs. Crompton and Co.

LUMINOSITY.—Hittorf, in recent experiments, using iridium for platinum and 2,400 elements, found that though the iridium anode was melted, the gas media, whether of nitrogen, hydrogen, or oxygen, remained perfectly dark.

ELECTRIC LIGHT IN HOTELS.—As part of the improvements introduced on their new service to the continent by the Great Eastern Railway Company, the Parkestone station refreshment rooms and hotel are lighted by electricity.

TELEPHONE CONSOLIDATION IN AMERICA.—All the New England exchanges, including those owned by Lowell and the Boston Exchange, are to be consolidated into one company under the title of the New England Telephone Company.

THE VIENNA EXHIBITION.—Owing to the slowness with which exhibits are arriving at Vienna, the exhibition, the opening of which was fixed for 1st August, has been postponed, no date for its commencement being yet decided upon.

ELECTRIC LIGHT AT THE HOUSE OF COMMONS.—The experimental lighting of the dining room and library of the House of Commons by electricity has, it is said, been so successful that the system is to be adopted for a permanency.

THE COMMITTEE ON THE PROVISIONAL ORDERS.—The evidence taken before this committee is lengthy and interesting, but we are compelled to leave the consideration of it for another issue, preferring to deal with it as a whole rather than in parts.

MAXIM-WESTON COMPANY AND THE CITY LIGHTING.—Mr. H. Watt, managing director of this company, writes to *The Times* that "after mature consideration" the Board have decided to discontinue their City lighting, because it is unprofitable. How, under the circumstances, could it be otherwise?

SOCIETY OF ARTS CONVERSAZIONE.—The *conversazione* held on Wednesday evening at the Fisheries Exhibition, was in every respect a great success. There was a large attendance, and the gardens, as well as the annexes of the exhibition, were lit by thousands of electric lamps and Chinese lanterns.

A HIGH RETURN.—Mr. Weston is said to treat gun cotton to form the filament for an incandescent lamp, and thus to get a carbon wire 75 ohms resistance, and expects with an E.M.F. of 52·5 volts, and a current of ·7 ampere, to get a theoretic efficiency of 20·3 lamps per horse-power, and a practical efficiency of 11 lamps per horse-power.

"THE ELECTRICAL REVIEW" (American).—This paper is appropriating Mr. Sprague's work on secondary batteries, as given in the *English Mechanic*, but so far without giving any credit to the paper in which the articles originally appeared. Our American friend may see a difference, which we fail to see, between stealing literary matter and stealing one's coat.

EASTERN EXTENSION TELEGRAPH COMPANY.—We understand that this company is about concluding an agreement with the French Government with a view to the laying of two new cables in the Eastern seas. These cables will connect Tonquin and Saigon, also Hong Kong and Saigon. The former is to be completed within four months of the present time.

FRENCH ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.—The twelfth meeting of this association will be held at Rouen, from the 16th to 25th August. Besides the papers to be read, a number of excursions are being arranged to Elbeuf, Dieppe, Havre, and Cherbourg, but the programme is not yet definitely settled. The town of Rouen itself possesses many attractions.

"GORDON'S PHYSICAL TREATISE ON ELECTRICITY."—We understand that the new edition of this work will be ready next month. The work has been revised throughout and considerably enlarged by the addition of new matter and illustrations. Full accounts will be found in it of the experiments of Bjerkness, Stroh, and Tribe. The publishers are Messrs. Sampson Low and Co.

TELEPHONY AND MORALITY.—A curious case has recently come before the American Courts. A telephone company stopped communication with a subscriber because the language used mainly consisted of expletives, and was unfitted to reach the ears of many who might accidentally overhear it, such as the young women employed in the exchanges. The company was upheld by the Court.

OVERHEAD WIRES IN TOWNS. — At the meeting of the Liverpool Workhouse Committee on 19th inst. the increasing multiplicity of telephone wires overhead was discussed upon a recommendation to allow the Liverpool Telephone Company permission to fix a support for a wire upon the top of the workhouse. Several members expressed anticipations of danger from the network now covering the city. The application in question was postponed for a fortnight.

LIVERPOOL.—The Liverpool Electric Supply Company have fitted up Eberle's restaurant in Dale-street with Woodhouse and Rawson's incandescent lamps. The dynamo is

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driven by a gas engine, and steadiness of light is secured, and risk of breakdown obviated by the use of storage batteries. As this establishment requires artificial light all day, the advantages of electric light over gas are most marked. The installation has been effected under the superintendence of Messrs. Holmes and Vaudrey.

House Lighting by Batteries.—As we suspected, the daily papers are quite wrong about the pretty exhibit of the Leeds Forge Company at the recent Metal Trades Exhibition. The large marine boiler, fitted up as a drawing room, was lighted not by "storage batteries," but by primary batteries, the company supplying them being the Economic Electric Company, of Rathbone-place and Soho-square. The battery employed was an improved form of Daniell, with modified solutions. The installation, thanks to the portable nature of the generator, was put up in a few hours, and ran successfully to the end.

Atlantic Cables.—Most of our exchanges, and many of the English correspondents in America, amuse themselves from time to time in spreading canards about more Atlantic cables. A note in our last issue, under the heading "Sheepish," has brought more than one reply showing the ignorance of the ordinary reporter; and as we then said we could without much difficulty lay our hands upon the paper originating the error, so we could without difficulty show how these statements about Atlantic cables arise. Generally there is no foundation for the rumours, except words purposely said to keep unsettled, and to allow of manipulation on, the Stock Exchange.

The Postmaster-General's Report.—The twenty-ninth annual report of the Postmaster-General just issued shows that there has been an increase of 746,156 in the number of telegrams during the past year as compared with an increase of nearly two millions in the year 1881-2. This diminution in the rate of increase is partly accounted for by the occurrence of two Easters in the financial year. The total number of telegrams amounted to 32,092,026. The sum of £37,000 has been spent on improved telegraphic communication with Ireland, and £13,000 for the new cable depôt at Woolwich. It is contemplated fitting up a cable ship at a cost of £46,000 the department at present having no cable ship of its own.

Eccentric Electricity Underground.—During a heavy storm a week ago, while the guides were showing a large party through the Luray caverns in Virginia, the lightning struck one of the electric light wires and was carried into the caves, while it ran over the wires from one end to the other. The electric light globes were shivered into fragments, and the lightning gathered into big balls along the wire and exploded with loud reports. The scene for several minutes was terrific beyond description. The lightning flashing along wires looked like fiery serpents. One bolt shot from the wires and scattered the stalactites of the bridal chamber. When it disappeared, some of the party were left in total darkness.—*Electrical World.*

The Electric Light in Newington.—An inquiry was opened on Saturday last before Major Marindin, R.E., on behalf of the Board of Trade, at the Vestry Hall, Walworth-road, with respect to the application of the Newington Vestry for a license to supply the electric light, which was opposed by certain ratepayers.—Mr. Littler, Q.C., who represented the parish authorities, said the vestry had applied for a license for the whole parish, but sought only to make it compulsory over a small portion, and that at present it would only propose to spend £20,000, which would not increase the rates more than about one penny in the pound.—Mr. L. J. Dunham (vestry clerk) was examined, and said that the resolution to apply for a license was carried by 26 to 11.

Cheap Telegrams.—In the House of Commons, on the 19th inst., Mr. R. Paget asked the Postmaster-General if he would be good enough to consider the advisability of establishing a cheaper rate for telegrams sent from the country to London (or any other populous place having two or more postal deliveries during the day), subject to the condition that such telegrams should not be specially delivered, but should be sent to their address by the earliest available postal delivery of letters.—Mr. Fawcett replied that careful consideration had been given to the proposal contained in the question of the hon. member, but it was not thought desirable to depart from the principle, which in his opinion was a very important one, of maintaining uniformity of charge.

Forged Telegrams.—It is stated that on Monday morning a large number of forged telegrams, purporting to be sent by Dublin stockbrokers, were forwarded to brokers in London ordering the purchase and sale of large quantities of stock. Fortunately some circumstances occurred in London to arouse suspicion, and the consequence was the telegrams were not acted upon. An inquiry has been instituted, but as the messages were hand printed it will be probably difficult to trace their authors. By the Post Office (Protection) Bill, now before the House of Commons, Mr. Fawcett will propose to render liable to twelve months' hard labour any person "who forges a telegram, or utters a telegram knowing the same to be forged, whether he had or had not an intent to defraud."

International Electrical Exhibition, Vienna, 1883.—As far as time and space will allow, a fountain is to be erected in the centre of the Rotunda similar to the fountains in front of the St. Peter's at Rome. By a pump, driven by electricity and requiring 40 horse-power, a considerable quantity of water will be conveyed to a height of from seven to eight metres, falling into an intercepting vessel below, and from there into the basin, which will likewise have its water columns play during the exhibition to a height of 25 metres. The Société Gramme, from Paris, who exhibited for the first time at the Universal Exhibition in the year 1873 the electric transmission of force by driving a small pump, and employed about 2 horse-power, will carry out the installation above mentioned, and exhibit the engines then employed as historical models.

The Edison Light in Italy.—On the 28th of June the Comitato per le Applicazioni Dell' Elettricità Sistema Edison in Italia inaugurated the central station for electric lighting in Milan with a *soirée* in the Teatro Manzoni. The central station of Milan, erected near the cathedral, has now four Edison 1,200-lamp dynamos, and has room for eight more dynamos of the same size. The construction began in November, 1882, and the plant was ready to start in June, 1883. The company made contracts for supplying light to 3,500 lamps, especially for cafés, restaurants, clubs, and some stores in the most frequented part of the city. In the district which is supplied with Mr. Edison's underground system, there are two theatres, one of which is the celebrated Theatre Della Scala, which will be completely lighted for the end of this year with about 2,000 lamps. The station is now working regularly with about 500 lamps, to be increased daily as the wiring of the lamps is completed.

The Electric Lighting Act.—A parliamentary paper has been issued containing the report of the Board of Trade respecting the applications to and proceedings of the Board under the Electric Lighting Act of 1882. From this state-

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ment it appears that by the 21st of December last, the date prescribed by the rules which the Board of Trade has issued. 106 applications had been received. Twenty-three of these were promoted by local authorities, and eighty-three by companies; ninety-seven of the applications related to places in England and Wales, eight to places in Scotland, and one to Belfast, Ireland; thirty-five related to London and the suburbs. A list of the applications is given in an appendix. A fee of £50 was received with each application, and in ten cases where separate orders have been granted for various districts included in one application an additional fee of £10 has been charged by the Board of Trade. The total amount of fees received amounts to £5,400. The time for lodging objections was limited by the rules to two months from the date of the first advertisement of the application. It was, however, extended by a new rule to the 1st of February. Eventually, after a consideration of the orders as deposited, and of the objections which had been lodged against them, the Board of Trade determined upon the principles upon which the applications should be dealt with, and on the 28th of February they circulated model clauses for adoption with such modifications as might appear to be necessary. The charges to the public are more than covered by the fees received. The report is supplemented by several appendices.

Electric Lighting of the Strand.—Sir Frederick Bramwell, C.E., gave evidence on this question on Tuesday before the Select Committee of the House of Commons on Electric Lighting. He said he had given a great deal of attention to electric lighting, was a shareholder in the Edison Company, and had seen the system of that company at work in New York. In his opinion the Edison Company could supply electricity in the Strand district as cheaply as any other company. They would have to lay down mains, and might find themselves working for one or two years at a loss. Gas was likely to become cheaper every day, and would be the strongest possible competitor. No doubt, Sir Frederick Bramwell said in cross-examination, at first, light for light, electricity would be dearer than gas. It would be equal to a price of 7s. 6d. per 1,000 feet of gas. A man might be willing to pay 50 or 100 per cent. more for a light he preferred than for gas. At any rate, for a long time the prices would be widely different. Sir John Lubbock, chairman of the Edison Company, stated that Mr. Edison was to have half profits after 5 per cent. was paid to the shareholders. Mr. Edison would receive £20,000 by anticipation, to be repaid out of profits. Evidence was also given by Dr. Hopkinson, electrician of the Edison Company, and other witnesses. The question immediately before the committee was the confirmation of the provisonal orders obtained by the Edison and Swan companies for the electric lighting of the Strand district. These two companies are working in harmony, but are opposed by the Strand District Board of Works, and partially by the Jablochkoff Company, who seek admission into the district.

A New Enemy of the Telephone.—A delegation of telephone subscribers from the Eighteenth Ward called at the office of Superintendent M'Kinstry yesterday afternoon, says the Cleveland *Herald*, and complained that some new wire that had been strung along through that ward was interfering with the workings of their telephones, at times rendering them perfectly useless. The wire was discovered to be that of the Postal Telegraph Company. On Harvard-street, east of Broadway, and on the Bedford-road, the postal line runs within eight or ten feet of the telephone line for a distance of three or four poles, and although an ordinary wire at the distance would produce no effect whatever, the system of telegraph in use by the Postal Company renders the telephone line almost of no value. The sound produced by the enormous induction from one heavy copper wire of the Postal system is much like that of a fish-horn. While the Leggo system of telegraph, which has already been described in these columns, was used over the new company's wire, some trouble was anticipated in the working of the telephone, but it was not thought a material difficulty. Afterward, however, the Gray harmonic system, which the *Herald* has also described, was put in use on the line, and the induction was so great that much complaint began coming in. At first the owners could not imagine what was the difficulty, and even electricians did not believe it possible that wires so far distant could produce the effect. It appears, however, that the system now in use over the line is particularly conducive to heavy induction, and the wires will be raised still farther away from the telephone line. Mr. M'Kinstry appeared before the Board of Improvements last night and asked for permission to have the wire changed, which was granted him.—*Electrical World.*

An Electric Railway.—The Electric Railway at Wimbledon, which it was expected would have carried passengers during the recent Rifle Association Meeting, made a start on Friday week; and a train, with Earl Brownlow, Sir Henry Halford, and eighteen other members of the association, ran the length of the line, about a mile, at a speed (six miles an hour) which earned for the engineer the congratulations of the party. The experiment has been, unfortunately, a rough one, and the conditions under which it has been carried out are very detrimental to the reputation which the system is susceptible of attaining. The familiar track of light rails laid down twenty-two years ago, with carriages of the same date, the sleepers loose in the sandy soil, is not the kind of line for an electricity-driven train to be shown off upon, especially when the wheels of the cars are so much furrowed that their bearing surfaces bump on every chair of the rails they pass over. The system of propulsion is by current generated from a Weston dynamo, worked by a 12 horse-power Robey engine, and conveyed and returned by two flat copper bands about an inch broad, each laid at the bottom of a groove in long wood bearers stretched midway between the lines of rails, and supported on square wood blocks saturated with pitch. The insulation appears to be perfect. The motor consists of four external magnets coupled together in similar poles, and an armature formed of sixteen magnets travelling in the interval between the external magnets and cutting all the lines of force. It is mounted on one of the ordinary carriages, and the current is drawn off from and returned to the conductors by two trailing chains dropping within the conductor channels. The system has been put under trial by the Electric Motor Syndicate, the motor being the invention of Mr. Brown. The line is not being worked to the full extent of the power furnished, the engine only making 40 revolutions and the dynamo 300, whilst the normal rate of the latter should be 900 revolutions.

Lighting of the Steamer "Pilgrim."—The *Sanitary Engineer* of New York, in an article on the plumbing and lighting of this new steamer, of the Fall River Line, between Boston and New York—a steamer supposed to be the largest inland steamboat in the world—says of the lighting that it "is entirely by electricity. This work was done by the Edison Company for Isolated Lighting. The plant consists of one 'L' and two 'K' Edison dynamos, run by a special engine of about 100 horse-power, and some 940 incandescent lamps; of these about 550 are of 10 candle-power, and

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the rest of 16 candle-power. The latter are used for general illumination, mostly in the grand saloon, gallery, and main deck, and the smaller lamps for the state rooms, passage ways, and other smaller compartments. The wiring is done in much the same manner as in a large building. It is divided into four systems on each deck, with the idea of preventing the loss of more than a few lights in case of a collision or other accident. Each section has a cut-out near its junction with the main, and each single lamp has a separate cut-out as usual. The large electroliers in the grand saloon are divided into four sections, each controlled from a small closet in the gallery opposite, so that the majority may be readily turned off, while a few are allowed to shine all night. While the dynamos are ordinarily run from their own boiler, they may also be connected if necessary with the main or donkey boilers. The engines are run at a uniform speed, the intensity of the current being adjusted by Edison's automatic regulator, which 'cuts' in more or less resistance according to the number of lights burning. A great superiority of the incandescent electric light over all other forms of lighting vessels is claimed, and apparently with reason, since they do not vitiate the air, are not affected by the wind or motion of the boat, do away to a great extent with the use of matches, and will not set anything on fire in case of collision or other accident. It seems to give perfect satisfaction in every way, and we understand it is proposed to substitute it for gas on the 'Bristol' of the same line."

Electric Lighting Provisional Orders.—Several Bills for the purpose of enabling various electric lighting companies to take steps for lighting streets, and in some cases domestic houses, in several districts of London and in various provincial towns, came before a hybrid Committee of the House of Commons for the first time, on Thursday week, Mr. Sclater Booth presiding. The committee room was filled with parties interested in the questions at issue. Mr. Farrer, Secretary of the Board of Trade, gave full and comprehensive evidence, occupying the whole afternoon, on the action of that department in relation to this subject. The Act of last Session, he said, conferred powers upon electric lighting companies to break up the streets, and gave power to the local authorities to spend the money of the ratepayers in connection with these undertakings. These powers were limited to seven years, which were probably not sufficient to develop the capital in those undertakings. It was therefore provided that the Board of Trade might grant provisional orders for unlimited periods, with or without the consent of the local authorities, but after consultation with them. It was felt that, while the local authorities represented the ratepayers, they were in many cases inert bodies, not likely to introduce new things, who might be interested in gas, and who were by no means certain to give the ratepayers the benefit of this new invention. Monopoly in gas was obtained by the use of streets, but, as far as the department could judge, there was no reason why several wires should not be laid in the same street, and there was no reason why the Board of Trade should not grant a fresh license the moment an existing company did not do its work properly. 106 applications were received by the Board of Trade, of which 23 were promoted by local authorities and 83 by companies; 35 related to London and the suburbs, 57 of the applications were embodied in provisional orders, and 47 were rejected or withdrawn. The Bills immediately before the committee included those relating to Westminster, St. James's, the Strand, and South Kensington, all of which were opposed.

Picking up Cables.—The following from the *Age of Steel* is quoted or taken without quoting by several American contemporaries:—"The laying of telegraphic cables is now so common that the description of the machinery for picking up a broken one will be read with interest. It consists of a rope about an inch and a quarter in diameter, made from the strongest hemp, with interwoven wires of fine steel. The grapnel at the end is merely a solid shaft of iron some two feet long, and weighing about one hundred pounds, and prolonged into six blunt hooks, which much resemble the partly-closed fingers of the human hand. In picking up the cable in deep water the "Minia," after reaching the waters near the break, lets out her rope and grapnel, then takes a course at right angles to the cable and at some distance from the fracture, so that the broken ends may not slip through the grapnel. The grapnel rope is attached to a dynamometer, which exactly measures the strain on the rope, and shows unerringly when the cable has been caught. If the grapnel fouls a rock the strain rises very suddenly to a high point; but the exact weight of the cable being known, the dynamometer signals by the steady rate of increase its hold on the cable far below. The ease and certainty with which cables are picked up in these days are amazing. A while ago one of the lines of the Anglo-American Company was caught without trouble at a depth of two and a quarter miles near the middle of the Atlantic. Captain Trott, of the "Minia," who has won great fame for his skill and ingenuity in cable matters, but recently picked up the French cable 180 miles off St. Pierre, and in four hours from the time the grapnel was let go had the cable spliced and in working condition. The splicing is a work of great delicacy and skill, and when accomplished by trained fingers the spliced part can scarcely be distinguished from the main cord. So rapid has been the improvement in perfecting the modern cable, that the resistance to the electric current has been reduced to one-quarter what it was twenty years ago, while the duplex system of sending and receiving messages doubles the capacity of every new cable laid."

Telegraphy and Journalism.—"It seems to me," writes an experienced journalist in Paris, "that the prevailing system of journalism defeats the objects of the newspaper, which should not aim at being a mere reverberating gallery. If a great event happens to-day in one city the journalistic correspondents will telegraph to-morrow from all the other capitals where they are posted what is said there about the event in question. Would it not be better if they related what was being done? The opinion of Madrilenes on, say, a terrible agrarian outrage in Ireland given on a hastily-written telegram is not worth having, but it would be very interesting to know how the Spanish Government was endeavouring to gag the press, and how the editors met the attempts to curtail their liberty. There is not one Madrilene in ten thousand who has been in Ireland, or who is at the trouble of forming a correct opinion on an agrarian outrage there. When the late Czar was assassinated it would have been interesting to have obtained personal reminiscences about him from Madrid, Berlin, New York, or any other city; but I cannot conceive any Frenchman caring a straw to hear what an ordinary English journalist thought upon the subject, or *vice versâ*. A Spanish correspondent should confine himself to keeping a record of the national and social life of Spain, an Italian to that of Italy, and so on. The journalistic effect of telegraphy is to bewilder and prevent us having clear and connected ideas on foreign affairs. There used to be sequence in foreign correspondence. Since special wires were set up, there has been none. The other day I had occasion to make searches in a file of newspapers, and

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was struck with the incoherency of the telegraphic record. I wanted to obtain a retrospective view through the English journals of events that had taken place here at about the time that the Phœnix Park murders were committed. But the thread of French daily history was completely broken. What was sent over the special wires were opinions formed hastily at absinthe-hour by French journalists, who wrote about the double murder because they were obliged to write, and not because they had something to say."—*Pall Mall Gazette.*

Strike of American Telegraphists.—The agitation amongst the telegraph operators of the principal American telegraph companies for an increase of wages, which at one time showed signs of terminating in an amicable arrangement, culminated in a strike on Thursday week. The men had been organising for a considerable time past, and had recently entrusted the management of the movement to a committee composed of their most influential and trusted *confrères.* The telegraph directors seem to have altogether underrated the extent of the dissatisfaction and the consequent strength of the movement, and Mr. Eckert, a prominent official, went out of his way to sneer at the operators' committee. He publicly asked the committee "Whom it represented?" and the men say that their action is their answer to Mr. Eckert. On Thursday afternoon work was proceeding in the Western Union Offices, New York, in the customary manner when suddenly the shrill sound of a whistle was heard. This was the preconcerted signal for the strike. Immediately the operators "rose like a flock of birds," as an eye-witness of the curious scene describes it, amidst ringing cheers, wild gesticulations, and other signs of excitement, and fully 90 per cent. of them rushed tumultuously from the building. The news of this action quickly spread, and in a short time the Western Union men were joined by the operators of the Ohio and Rapid Telegraph Company. About 375 operators struck work in New York alone. Their example was followed at Chicago, Washington, Baltimore, Cincinnati, Philadelphia, Boston, and other places. The operators claim that ten thousand clerks are members of the organisation, and that their funds amount to nearly a quarter of a million dollars. They are also members of the Knights of Labour, a very numerous and powerful body, embracing various trades, and pledged to support their affiliated bodies when on strike. The average monthly wages of telegraph operators in the States is 54dols.; in Canada it is 37dols. The Western Union Company calculates that to grant the increase demanded would involve an expense of one and a half million yearly, while the cost of fighting the brotherhood will be one million. Much sympathy was felt with the operators, but the belief prevailed that the company would win. The produce exchange business has stopped. It is believed that two hundred cities will be affected by this occurrence. Mr. Jay Gould has sustained the quotations of the Western Union. By Friday morning the movement had grown to formidable dimensions, 7,000 male and 1,000 female operators, according to the *Daily Telegraph's* correspondent, having left work. He stated that popular feeling is strongly in their favour, and will, if they do not injure their cause by violence or intimidation, exercise a powerful influence in the struggle. The Western Union Telegraph Company have announced their intention of straining every nerve to defeat the strikers, and the latter are, to all appearance, equally determined. On the whole, the chances of success are thought to be in favour of the operators. Meanwhile the public are the sufferers. Private telegrams are greatly delayed, the news services to the various daily journals are completely blocked. All the newspapers this (Friday) morning comment freely upon the strike. The *Sun* says the Brotherhood of Telegraphists has given an illustration at once interesting to philosophers and instructive to corporations, and compares the progress in industrial strikes with the improvements in modern warfare.—The *Herald* is of opinion that the telegraph companies have incurred grave responsibilities to the public, which will compel them either to make terms with the strikers or to promptly engage efficient substitutes. No public corporation has a legal or moral right to jeopardise the business of the country by the attempt to succeed in a dispute with its *employés* about wages.—The *Tribune,* which it is as well to bear in mind is the organ of Mr. Jay Gould, the virtual proprietor of the Western Union Company, denounces the brotherhood as a secret, oath-bound organisation, and says they ought to have resorted to arbitration for the settlement of the dispute.—*The Times* asserts that the Western Union Company, by its cavalier treatment of the brotherhood, has succeeded in enlisting the sympathy of the public wholly on the side of the operators. The companies should put themselves without delay in a position to perform to the fullest extent the functions for which they were chartered.—The *World* believes the strike will not be a success, except so far as to harass commerce and temporarily impede the facilities for the transmission of news.—By Friday evening it was found that only about one-eighth of the telegraphic clerks had remained at their posts, and upon these there was necessarily thrown an enormous amount of work. The telegraph companies have closed a few of the local offices and offices recently opened, and are concentrating their efforts at the principal centres. The United Press Association have conceded the advance of wages to the few operators they employ. The general news service is much delayed, but the newspapers having special wires are pretty fully supplied.—By Sunday the strike had spread to Washington, Baltimore, and thence along the Pacific coast, the stress for want of operators being especially severe at Chicago and St. Louis. The companies offered a reward of 500 dollars for the arrest of any one tampering with the wires, but there is no evidence that the men on strike have any intention of molesting them. The traffic was disposed of with some difficulty, and it is thought that it has been reduced by one-half owing to the abstention of the commercial classes from sending telegrams under present state of things. On Monday evening the ranks of the strikers had been so far recruited that they numbered, it was said, about seventeen thousand. Some of the smaller companies have come to terms with their men, but the Western Union are, it is suspected, so much embarrassed by the continued defection from their staff that a demand upon the railway companies to despatch private messages is hourly expected. In that case the railway telegraph operators will follow the example of the Western Union telegraphists.—The *Standard's* correspondent, telegraphing from New York on Tuesday night, stated that business was suspended at eight thousand of the twelve thousand offices belonging to the Western Union Company, and that the loss is estimated at twenty-five thousand dollars per day. *The Times'* correspondent gives the probable rate of daily loss as one hundred thousand dollars. Some other companies, including the Great North West of Canada, are said to be on the point of granting the demands of the men.—On Thursday intelligence from New York was a little more reassuring, there being some talk of an understanding being arrived at, the Produce Exchange Company acting as arbitrators. Traffic, it is stated, is now being disposed of with less delay, but it is immensely diminished in quantity.

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CURRENT ENERGY.—VI.

BY OLIVER HEAVISIDE.

After Ohm's law, the Conservation of Energy demands consideration. For Joule's law, which naturally follows Ohm's, is an example thereof, and as it happens that in current electricity we meet with some of the most important and practical, as well as scientifically interesting, applications of this great modern generalisation (made the more interesting by our ignorance of the connecting mechanism) it will save future repetition to here briefly discuss it from the standpoint of theoretical dynamics. One may indeed gain, as most educated people have gained, by often reading about it, or from popular lectures, without previous study of dynamics, a general notion of the conservation of energy, and accept the principle as an article of faith, and at the same time have very vague ideas as to what is meant by energy, or why it should be conserved. Nothing will supply the deficiency save a careful study of dynamics, a repulsively dry subject to most, but, owing to the far reaching of its principles, one whose preliminary study is indispensable to those who wish to form correct ideas in electricity and magnetism. Not that they will thereby learn what electricity and its connected functions are, but rather that they will know certainly what they are *not*, and hence be able to avoid the absurdities arrived at by those who ignore dynamical relations.

Now, in theoretical dynamics the conservation of energy is a necessary consequence of Newton's laws of motion, with our definition of what we mean by a force doing work. A force being what causes, or tends to cause motion, is naturally measured by the amount of motion caused. Measuring the force acting upon a free particle of mass m by the rate of acceleration of its momentum, mv, where v is the velocity (relative to a body assumed to be at rest, or to bodies not in relative motion), and calling F the force, we have $F = m\dot{v}$, the dot indicating rate of time-increase (Newton's notation.)

Also, work is spent by a force when its point of application moves with the force, and work is done against the force in the reverse case, which is exemplified when a stone falls to or rises from the ground with or against the force of gravity. A force F acting through a distance x does work of amount Fx. In the general case, F must be taken as the force acting in the direction of motion, the component in that direction of the actual force. Thus the downward force of gravity does no work on a body moving horizontally.

Since v the velocity is the distance moved per second, with the proper qualifications for varying velocity as the distance that would be moved through per second if the velocity kept constant, we have Fv as the work done per second, the rate of working, or the activity. But since $F = m\dot{v}$ we have $Fv = mv\dot{v}$, and the latter is the same as $\frac{d}{dt}\left(\frac{1}{2} mv^2\right)$. Calling the quantity in the brackets the kinetic energy, and denoting it by T, we have $Fv = \dot{T}$ always. That is, the rate of working of the force equals the rate of increase of the kinetic energy of the mass moved. Hence the work spent by the force in increasing the velocity from v_1 to v_2, however the force may vary in the interval, is exactly equivalent to the whole increase of kinetic energy $T_2 - T_1$, or $\frac{1}{2} m (v_2{}^2 - v_1{}^2)$.

The quantity T, the equivalent of the work spent in producing the motion from rest, is conversely the amount of work the body can do in coming to rest by moving against a force, hence the propriety of the term kinetic (*i.e.*, motional) energy. For we have now retardation instead of acceleration of momentum, work done against, instead of by the force, and by a reversal of the previous reasoning the total work done when the body is brought to rest is exactly T, the initial kinetic energy.

Thus, project a body upward with initial velocity v, it will rise to such a height h as to do $\frac{1}{2} mv^2$ work against the downward force of gravity g; that is $\frac{1}{2} mv^2 = gmh$ gives us the greatest height it will ascend. Gravity still acting, the body will return, and on reaching the ground have the same velocity and kinetic energy as at first. That is to say, the original kinetic energy, although wholly lost at a certain height, is completely recoverable on allowing the mass to return. The energy, when it has thus disappeared from the kinetic form, but is recoverable, is called potential energy, or energy of position. To whatever height the body may have ascended at any moment, with a certain loss of kinetic energy, exactly the amount lost is recoverable, and hence is to be considered potential energy. At the greatest height, where the velocity is *nil*, the potential energy equals T_0, the initial kinetic energy, whilst on starting from the ground and on reaching it again the potential energy is *nil*, and in any intermediate position the sum of the kinetic and potential energies is T_0, and remains constant throughout the motion both ways.

Potential energy, or work obtainable in virtue of position, is a more abstract idea, seemingly, than kinetic energy, but the two are quite co-relative, and one is as easy or as hard to understand as the other. Force of some kind is equally involved in kinetic and potential energy, when there is change from one to the other. Force produces relative motion and its kinetic energy, and the latter cannot be utilised without force. In the above simple case the conservation of energy only means that when kinetic energy is lost by the body moving against the force, such loss is perfectly recoverable in the return motion, since the force remains the same in the same places. This last remark, indeed, contains the reason why the energy is conserved, or returnable to the kinetic form.

Consider a system of free particles in motion on which no external forces act, the forces being wholly mutual stresses, say attractions or repulsions, which vary only with distance, so that the force between two particles is the same at the same distance apart, whatever be their actual positions. Let the system move from any one configuration through any series of intermediate configurations, back again to the original. During the cycle, any two particles which approached or receded from one another during one part, recede from or approach one another the same distance in the remainder of the cycle. The work done by the mutual force in the first part is therefore exactly equal to the work done against the force in the second part of the cycle, and this applies to every pair of particles. Hence the whole work done by the forces during the cycle is *nil*, and the kinetic energy at the end of the cycle is the same as at the beginning. (To make the particles return to the original configuration without alteration of energy, the artificial plan of frictionless constraints may be adopted, *e.g.*, guide a particle through a perfectly smooth tube of any form desired under the action of the given forces; the constraining force of the tube will be always perpendicular to the direction of motion of the particle, and no work will be done by it.) Further, the kinetic energy in *any* configuration will be a function of the configuration only, *i.e.*, in whatever way the particles move from one configuration to another, the gain of kinetic energy, being the total work done by the forces, will be the same, for the forces depend only on the configuration.

Defining, then, the potential energy V of the system in any configuration A to be the work spent by the forces when the system moves from A to a standard configuration chosen arbitrarily, and T the kinetic energy in the state A, it follows that $V + T$ remains constant in every configuration. In the standard state $V = 0$ (or any constant value we like); any departure from that state which is attended by an increase or decrease of kinetic is attended by an equal decrease or increase of potential energy, meaning that the decrease of kinetic energy is regained or the increase lost by letting the system go back to the standard state.

If we have two such systems of particles, each with internal forces alone, their energies are naturally independent and remain constant as above. But should there be force between one system and the other, energy may pass between them, and now it is the two systems as a whole, considered as a single system, that is conservative.

We may pass from systems of particles to the ideal rigid bodies of mechanics, which cannot change shape, by intro-

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ducing constraints. Let any collection of particles be constrained to always preserve the same relative positions, to become, as it were, a rigid body. No work can be now done by the mutual internal forces if they be pulls or pushes along the joining lines between the particles, since the relative motion of any pair must be always perpendicular to the line joining them. Hence the internal forces wholly disappear from the equations of energy, and only external forces need be considered. Any collection of such rigid bodies with mutual forces preserve the sum of their kinetic and potential energies constant, unless work be done on the system from without, when the amount of such work is the gain in its total energy. Practically, rigid bodies which do not change their form appreciably under not too great external forces, though their parts may be in irregular motion, come under the same law, from the experimental evidence that the unknown internal actions do not tend to change their state of bodily motion, whether of translation or rotation.

Again, in the ideal perfectly elastic body, the work spent by external forces in changing it from one form to another against the internal stresses is independent of the series of intermediate forms, and the energy thus put into the body is perfectly recoverable by letting it return to its original shape through the same or any other series of shapes, the stresses depending on the shape only, with consequent conservation of energy.

But the conservation of energy, in the limited sense in which we have employed the idea above, does not exist in Nature. Thus, when one body is set sliding over the surface of another, its motion is retarded, and it finally comes to rest. The force that brought the body to rest will not act back and restore the kinetic energy, which is apparently lost for good. Make the body move back over the same path, and there is a further loss of energy, for the frictional force is not the same in coming back, but is always against the motion, and, besides, it depends upon the velocity more or less. Again, the stone which, projected upwards with a given amount of energy, loses it all at a certain height, and recovers it all (or nearly, some being lost in friction against the air) on reaching the ground, suddenly loses it again, for there is only a small fraction in its first rebound. A portion of the energy may be traced in the vibrations set up in the masses in collision, but this is only a portion; whilst the vibrations themselves subside, and leave no trace.

Energy thus disappearing from view was formerly supposed to be lost, or, at any rate, it was disregarded. But the modern principle of conservation of energy teaches that energy is never lost, though it may not be recoverable directly. Being a broad generalisation from innumerable experiments, it must be regarded as an experimental law, whose observed fulfilment in so many cases leads us to believe that its truth is universal, and that in every case of disappearance of energy of one kind there is an equal gain in some other kind or kinds, no doubt ultimately resolvable into the simple kinetic and potential energies of dynamics, but usually of unknown exact nature, as the energy of a distribution of static electricity, probably the potential energy of a strained state of the medium, the energy of electric currents, or of magnetisation, or of chemical affinities. To enumerate all would be to range over all natural phenomena, but as we are confined to electricity, we need only mention preliminarily that it has been proved, and abundantly so, that heat is energy itself, requiring no multiplication by some other physical quantity to make energy, as is the case with electricity following, electric current, magnetisation, &c. A definite amount of heat represents a definite amount of energy, and the very important relation between heat in caloric units and mechanical, after being theoretically, though by what is considered unsound reasoning, calculated by Mayer, was experimentally determined by Joule, who, from a numerous series of experiments, found that 772 foot-pounds of work per pound of water frictionally spent in stirring it raises its temperature 1°F., a result confirmed in many other ways less direct, through other forms of energy. The quantity of heat required to raise the temperature of a pound of water 1°F. is therefore 772 foot-pounds, or of a gramme 1°C. is 42,000,000 ergs.

Now, whatever may be the ultimate nature of electrostatic actions, the quantities termed electricity and electromotive force are such that their product is energy, which is something definite, being work obtainable. That this is so follows from the definitions of electricity (quantity of electricity) and E.M.F., and elementary considerations. Thus, let a static charge Q be carried from a place where the potential is P_1 to a place where it is P_2, the whole E.M.F. along the path being $P_1 - P_2 = E$, say. Then the work done by E upon Q during the tranfer is EQ. For the electrostatic force f, or force per unit charge, is the space variation or rate of decrease per unit distance of the potential; the force upon Q is therefore Qf, and this is a real mechanical force (as in the common expression repulsion $= qq'/d^2$, q, is electricity and q'/d^2 electric force). Its space integral from the beginning to the end of the path is $Q\,(P_2 - P_1)$ or EQ, which is therefore energy.

Energy being thus the product of a quantity of electricity and an E.M.F., of course neither of the factors can be energy. That is, electricity cannot be energy, as heat is. Such a very obvious conclusion it might seem incapable of misunderstanding, yet there are men of standing who have failed to see the force of the argument, simple as it is. Can their failure have arisen from a want of acquaintance with the fundamentals of dynamics? If not, I can think of no other explanation than that the rapid whirl of their ideas, for they are men of imagination, may have produced some degree of oblateness of the spheroid.

Of course, if either E or Q were known the other would be known, since their product is a known quantity. But concerning the often-asked question, What is electricity? I can attach but little importance to the answer by itself. But the question, What is the mechanism of electrical phenomena? is quite another thing. For, if that were known, the functions E and Q would be known, and found to be worth—their full value. It *might* be then found desirable to completely alter the nomenclature of electrical theory, and instead of the present functions to employ others to which a plain dynamical meaning can be assigned. Of course the present established relations would remain true, but for them might be substituted equivalent relations in terms of better-understood quantities. But, naturally, until this desirable consummation is reached we had better keep to the present E and Q.

In $W = EQ$, where W is the work done by the E.M.F., E during the transfer of the quantity Q, we have supposed Q to be a static charge, and to be transferred by convection. That the same relation should hold when the charge is transferred by conduction, or when, as in a galvanic circuit, Q does not appear as a static charge at all, cannot be considered as immediately self-evident. For although experiment proves that a conduction current is virtually equivalent to the transfer of electricity, expressed symbolically by $Q = Ct$, where Q is the quantity transferred by the current C in time t, yet this relation is only a quantitative one. It suggests that there is actually motion of electricity round the circuit, and the current is popularly spoken of as such. But this must not be taken literally. There is an enormous difference between a state of electrification and the electric current which may produce it or be derived from it, and we cannot from electrostatic properties say what properties will be developed when a static charge disappears, and energy is transferred from a dielectric to a conductor. In the resulting phenomenon all trace of the electrostatic properties is lost, there is no external sign of any electricity in the conductor, whilst entirely new properties come into existence. As the static charge disappears, and the action upon static electricity likewise, or rather as the latter occurs and we infer the former, action upon a magnet at once appears in its place. The relation symbolised by $Q = Ct$ does not, without special hypothesis, imply the motion of electricity from place to place, meaning by electricity the quantity we make acquaintance with in electrostatics, in spite of the law that the current is the same in all parts of the circuit, and that it is virtually equivalent to convection of electricity.

The German philosophers seem determined, however, to have an electric current to be static electricity in motion round the circuit, and have made elaborate attempts, with

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much success, to find the law of force between two charges of electricity in motion, to include electro-dynamics as well as electrostatics. Weber gets over the difficulty of absolute apparent disappearance of the electricity as such by supposing an electric current to consist of two equal currents, one of positive, the other of negative electricity, in opposite directions, the currents being static electricity in motion. In any finite part of the wire there are always equal amounts of positive and negative electricity, and hence no external electrostatic force can be shown. This is, perhaps, the simplest way of evading the difficulty, and apparently far simpler than Clausius's hypothesis, wherein the very artificial plan is adopted of making a current in, say, the positive direction consist of positive electricity moving one way, with an equal amount of negative held fixed, or of negative moving the other way with an equal amount of positive held fixed, or of any combination of these opposite currents with their corresponding fixed charges, which will make the total current come right and balance the electrostatic force of the moving by that of equal amounts of fixed of the opposite kinds. It will be observed, however, that Clausius's hypothesis gives us much greater latitude than Weber's, which it includes as a particular case (although Clausius considers Weber's hypothesis unthinkable), viz., equal opposite currents, when of course the fixed electricities cancel, not being wanted.

Now, it may be that a conduction current really consists of convection of electricity on charged molecules, with intermolecular discharges, the continual cancelling of positive and negative charges being quantitatively equivalent to the transfer of electricity round the circuit, with no integral free electricity in any space containing a large number of molecules, but I have not as yet been able to conceive Clausius's hypothesis of the moving and fixed electricities. It will be observed that the German speculations contrast very strongly with the methods of the British school of electricians.

(TO BE CONTINUED.)

THE COST OF ELECTRIC LIGHTING AS COMPARED WITH GAS.*

(CONCLUDED FROM PAGE 237.)

Illumination of the Paris, Lyons, and Mediterranean Railway Good Station, Paris, by the Lontin System.—According to the report of M. Caël, Inspector of French Telegraphs, 18 Lontin-Mersanne lamps replace with advantage 250 gas-burners consuming 140 litres of gas per hour. The Lontin Company put the first cost of each of its lamps at 0·346f. per hour, including depreciation of plant at 10 per cent.; and the railway company pay for gas at the rate of 0·195f. per cubic metre; whence it follows that the cost of gas per Carcel per hour is 0·0273f., as compared with 0·0054f. for the Lontin light. Each Mersanne lamp has a luminous intensity of 600 candles, or approximately 64 Carcels; while the cost per hour of the Lontin system is as follows, under the supposition that there are 19 lamps:—

Coal for engine, 40 kilos., at 40f. per ton	1f. 60c.
Carbons, 1·70m. long	1 55
Oil and sundries for engine	0 80
Wages connected with engine, electric machines, and lamps	1 50
Interest and depreciation on plant (47,000f.), at 10 per cent. per annum, for 4,000 hours	1 17
Total (Lontin)	6f. 62c.

or 0·346f. per lamp per hour.

Illumination of the Avenue de l'Opéra, Paris, by 62 Jablochkoff Candles.—Mons. T. Lévy, engineer to the Paris Municipality, has thus established the cost per hour:—

Motive power	3f. 20c.
Coal for engine	6 64
Oil for lubrication	1 23
Wages of attendants	3 20
62 candles, at 50c. each	31 00
Total (Jablochkoff)	45f. 27c.

or 45·27 ÷ 62 = 73c. (7¼d.) per candle per hour. M. Leblanc, the gas inspector to the Paris Municipality, finds that the Jablochkoff candle, the light of which is reduced in passing through opal globes, gives an intensity of from 18 to 20 Carcels. The above cost must also be modified, as the price of the candles has been reduced to 30c., while they burn two hours. Instead of 62 × 50c., the figure will be 62 × 15c.; giving a cost per candle per hour of 38c. (3¾d.). As a gas-burner consuming 140 litres per hour costs 4·2c., the Carcel-unit afforded by the Jablochkoff system costs 2c. as compared with 4·2c. for gas.

Illumination of Arcade between Friedrichstrasse and Unter den Linden, Berlin, by Ten Siemens Regulators.—The cost per hour for a duration of 4½ hours is reported to be as follows:—

Consumption of gas by gas-engine, 8 cubic metres, at 25c.	2f. 00c.
Water for cooling cylinder of gas-engine	0 03
Engine driver	0 75
Oil for motor and electrical generators	0 20
Carbons	2 50
Total (Siemens)	5f. 48c.

Each lamp has an intensity of 50 Carcels. The cost of lighting this arcade by gas amounted to 12,000 marks (£600) per annum, while the electric light brought it down to 5,642 marks (£282 2s.), thus effecting a saving of more than 50 per cent.; but no account was taken of interest on capital and depreciation of plant. The installation must have cost 16,000f. (£640), which gives 97c. for interest and depreciation; so that the real cost of the electric light is 5·48 × 97c. = 6f. 45c. (5s. 2d.) per hour. Taking this item into account, the Carcel unit per hour will be 1·3c., as compared with 4c. for gas. If, however, a steam engine had been used instead of a gas motor, the current cost per hour might have been reduced from 5f. 48c. to 4f. 82·8c.

Illumination of the Rouen Quays by the Siemens System.—Three systems (those of Siemens, Jablochkoff, and Sautter-Lemonnier) were tried at Rouen. The table on next page gives the results yielded by the Siemens differential lamps. The cost per Carcel unit per hour has been established under the supposition that each lamp has an intensity of 476½ Carcels; but nothing has been added for interest on the original price of the motor nor its depreciation. The Carcel unit furnished by gas under similar circumstances ought to cost 0·025f. or 0·045f., according as gas is 15c. or 30c. per cubic metre (3s. 6d. or 7s. per 1,000 cubic feet).

Illumination of the Lachapelle Station, Paris, on the Northern of France Railway, by Four Serrin Lamps.—The following particulars are taken from a report by Mons. A. Sartiaux, assistant traffic manager on this railway. For an illumination of ten hours a day, the cost price per lamp per hour is—

Motive power, maintenance, and articles of ... consumption	0·556f.
Interest and depreciation on installation, at 10 per cent. per annum	0·243
Total (Serrin)	0·799f.

On the other hand, for comparison, gas costs 30c. per cubic metre (7s. per 1,000 cubic feet); and the cost per burner per hour is—

Consumption, 120 litres (4¼ cubic feet) per hour	0·0360f.
Interest and depreciation on a gas-burner, at 10 per cent. per annum	0·0016
Total (gas)	0·0378f.

* Abstract of a paper read before the Liege Association of Engineers, by Mons. J. Dumont, railway engineer to the Belgian Government.

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Number of lamps	4	6	8	10	12	16	20
Cost of installation	Frs. 4225	Frs. 4005	Frs. 5670	Frs. 6350	Frs. 8450	Frs. 10,130	Frs. 11,650
Interest and depreciation of do., at 12¾ per cent. per annum	538	625	723	810	1077	1291	1480
Interest and depreciation per hour for 600 hours of lighting per annum	0·89	1·04	1·20	1·35	1·79	2·15	2·47
Coal for motor, 2 kilos. (4½lb.) per horse-power per hour, at 30f. (24s) per ton — 4 h.-p.	0·24	...	...	...	...	...	...
5 "	...	0·30	...	...	...	...	...
6 "	...	...	0·36	...	...	...	...
7 "	...	...	...	0·42	...	...	...
8 "	...	...	...	...	0·48	...	...
9 "	...	...	...	...	...	0·54	...
10 "	...	...	...	...	...	...	0·60
Carbons, 10c. (1d.) per lamp per hour	0·40	0·60	0·80	1·00	1·20	1·60	2·00
Attendants and lubrication	0·30	0·30	0·30	0·30	0·50	0·50	0·50
Total cost per hour	1·83	2·24	2·66	3·07	3·97	4·79	5·57
Cost per lamp per hour	0·457	0·373	0·333	0·307	0·332	0·300	0·278
Cost per Carcel-unit per hour	0·00096	0·00077	0·00069	0·00064	0·00068	0·00062	0·00058

It has been ascertained that each electric lamp has an intensity of 100 Carcel units (96 candles) horizontally, which gives 200 Carcel units as the mean intensity. Whence it follows that the Carcel unit per hour produced by electricity comes to 0·0039f., and that by gas to 0·0376f.

Illumination of the Telegraph Office, Amsterdam, by the Siemens System.—According to data received from the Dutch telegraph Administration, the above office is lighted by five Siemens differential lamps, which take the place of 80 gas-burners consuming 155 litres (5½ cubic feet) per hour. Each gas-burner has a luminous intensity of 1·8 Carcel units; and each electric lamp, covered with an opal glass globe, yields about 36 Carcel units. The cost of production, calculated for an annual lighting period of 1,410 hours, is—

Electric Light.

Motive power, maintenance, and articles of consumption	4f. 83·0c.
Interest and depreciation on installation (15,540f.) at 10 per cent per annum ...	1 55·4c.
Total (Siemens)	6f. 38·4c.

or 4·53f. (3s. 7½d.) per hour.

Gas.

Consumption, by 80 burners, of gas at 21c. per cubic metre (4s. 10½d. per 1,000 cubic feet)	3671f. 64c.
Interest and depreciation on installation (4,000f.) at 10 per cent. per annum ...	400 00
Total (gas)	4071f. 64c.

or 2·89f. (2s. 4d.) per hour.

Whence it follows that the Carcel unit produced by electricity costs 0·0252f. per hour, and that by gas 0·02f., or a shade less.

Illumination of the Engine Works of MM. Carels Frères, Ghent, by Six Jablochkoff Candles.—It appears from a report by Mons. H. Backer that the six Jablochkoff candles supersede 126 gas-burners, which may be admitted to consume on an average three centimes, or rather over a farthing's worth of gas per hour, without taking into account interest on capital, depreciation, and maintenance; thus showing an expense of 126 × 3c. = 3·78f. (2s. 2½d.) per hour. Taking the actual duration of the candles at two hours, and the present price at 30c. each, the cost price per hour is—

Electric Light.

Electric candles	0f. 90c.
Fuel for engine	0 10
Attendance and lubrication	0 15
Interest and depreciation on 6,000f., reckoned at 15 per cent. per annum for 800 hours of lighting	1 13
Total (Jablochkoff)	2f. 28c. (1s. 10d.)

Gas.

Consumption of 126 burners at 3c. per hour	3f. 78c.
Interest and depreciation on 6,000f. reckoned at 15 per cent. per annum for 800 hours of lighting	1 13
Total (gas)	4f. 91c. (3s. 11d.)

Admitting that each candle has an illuminating power of 30 Carcel units, and each gas burner that of 1 Carcel unit, the cost of the Carcel unit produced by electricity is 0·0126f. per hour, and the same produced by gas 0·0389f.

Illumination of the Antwerp Docks Terminus by the Jablochkoff System.—The particulars communicated by M. Barlet, the engineer-in-chief and director of the lighting service, may be summarised as follows:—The number of lights is 48, of a luminous intensity of 40 Carcel units; and each requires 1 horse-power at least. The lighting is contracted for by the Jablochkoff Company for a period of ten years, at 65c. (6½d.) per light per hour for the first 50,000 hours' lighting in the year; and this price is reduced to 50c. (5d.) between 50,000 and 75,000 hours, when it is further reduced to 40c. (4d.). This light supersedes 160 gas burners (the placing of which is put at 100f.) (£4), on an average of 1½ Carcel power for a consumption of 150 litres (5⅓ cubic feet) per hour; gas at Antwerp being 0·161f. per cubic metre (3s. 9½d. per 1,000 cubic feet). Taking as a basis the cost of putting up the first 24 Jablochkoff lights, that of the 48 will be about 78,000f. (£3,120). At the rate of 40c. per light per hour, the Carcel unit produced by electricity comes to 0·01f. per hour, and

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that by gas to 0·0162f., or only a shade more. This lighting costs the Jablochkoff Company per hour:—

Motor—48 horse-power, at 7c.	3f. 36c.	
24 candles, at 30c.	7 20	
Supervision	0 50	
Interest and depreciation on 78,000f., at 10 per cent. for 4,000 hours of lighting	1 95	
Total	13 1	(10s. 5d.)

Under these conditions, the Carcel unit costs 0·0067f.

Illumination of the Fresnoy Slate Quarries, Angers, by Sautter and Lemonnier.—The cost of the installation of the light in a stall is as follows:—

2 Gramme machines	3,250f.
3 Serrin lamps (including one spare), at 400f.	1,200
1 box of sundries	75
Steam engine	10,000
Conducting wires	2,500
Total	17,025f.

The expense for 22 hours of work daily, including two hours of inspection and maintenance is:—

Coal consumed, 0·56 ton, at 30f. (24s.)	16f. 80c.
Carbon (22c. for positive pole and 12·5c. for negative pole), 11 pairs for 22 hours	8 40
Maintenance and lubrication (maximum) ...	5 00
Stokers and attendants four (men)	12 00
	42f. 20c.
Interest and depreciation on 20,000f. (£800), at 10 per cent.	6 60
Consumption of oil for miners, about.........	1 20

Total (Sautter and Lemonnier) ... 50f. 00c. £2 or 2f. 27·27c. (nearly 1s. 10d) per hour. Admitting that the Serrin lamp gives 300 Carcel units of light, the Carcel unit produced by this system costs 0·00378f. per hour; while the cost of gas lighting, with burners consuming 180 litres ($6\frac{1}{2}$ cubic feet) per hour, and of 1·6 Carcel power, is, with gas at 30·5c. (3d.) per cubic metre, 1f. 31c. (1s. $0\frac{1}{2}$d.); and this is all the expense, because it is needless to take into account the 10 per cent. interest and depreciation on the installation of 50f. (£2). Consequently, the gas burner costs 0·0544f. per hour, and the Carcel unit produced by gas 0·034f. per hour.

Installations of the Electric Light on Various Systems.	System adopted.	Cost per Hour. Of Gas per Carcel Unit.	Of Electricity per Carcel Unit of Direct Light.	Of Electricity per Carcel Unit of the Gaslight Superseded.
		Fr.	Fr.	Fr.
Telegraph Office, Brussels (Nord)	Jaspar	0·0265	0·0054	0·0544 (1)
Place des Nations Brussels	,, ...	0·0300	0·0052	0·0523 (1)
Goods Station (P.L.M.), Paris	Lontin	0·0273	0·0054	0·0248
La Chapelle Station, Paris (Nord)	Serrin	0·0376	0·0039	0·0371
Rouen Quays	Siemens	0·0333	0·00096 (2)	...
,, ...	,, ...	,,	0·00077	...
,, ...	,, ...	,,	0·00069	...
,, ...	,, ...	,,	0·00064	...
,, ...	,, ...	,,	0·00068	...
,, ...	,, ...	,,	0·00062	...
,, ...	,, ...	,,	0·00058	...
Arcade, Berlin	,, ...	0·04	0·01300 (1)	...
Telegraph Office, Amsterdam	,, ...	0·333	0·0252	0·0315
Telegraph Office, Brussels (Nord)	Jablochkoff ...	0·0265	0·0137	0·469
Avenue de l'Opéra, Paris.	,, ...	0·042	0·0200	...
Works of Carels Frères, Ghent	,, ...	0·389	0·0126	0·018
Antwerp Docks Terminus	,, ...	0·0162	0·0100	0·08 (3)
,, ,, ...	,, ...	,,	0·0067	0·0536 (4)
Fresnoy Slate Quarries, Angers	Sautter Lemonnier	0·034	0·00378	...

Remarks.—(1) One gas engine used. (2) Exclusive of interest and depreciation of motor. (3) Prices paid by Administration. (4) Prices calculated.

In conclusion, the above table sums up, in three columns, the cost of illumination per hour in the different cases named above. The first two columns give the cost of the Carcel unit per hour, produced both by gas and by electricity; and it must be borne in mind that (as observed above) the latter system involves the production of a total amount of light which is considerably above that required by gas lighting. To have a just idea, therefore, of the cost of both systems, it is not sufficient to compare the figures of the first two columns; account must also be taken of the number of electric Carcel units required to take the place of a gas Carcel unit. The cost thus ascertained is placed in the third column, the figures of which have been arrived at by multiplying those in the second column with reference to the total intensity in Carcel units produced by electric light and that produced in each individual case when the lighting was formerly effected by gas. For instance, in the case of the telegraph office at the Northern Terminus, Brussels, in which three Jaspar regulators, of 235 Carcel units each, replace 70 gas burners of 1 Carcel unit each, the cost of the electric Carcel unit—viz., 0·0054f. is multiplied by

$$\frac{235 \times 3}{70} = \frac{706}{70} = 10{\cdot}08,$$

which gives 0·0544f.; but, owing to lack of data, it has not been found possible to give the figures of the third column in all cases.

SCIENCE AND ART DEPARTMENT.

EXAMINATIONS, MAY, 1883.

SUBJECT IX.—MAGNETISM AND ELECTRICITY.

Examiners—Professor Frederick Guthrie and Professor G. Carey Foster, F.R.S.

The examination in this subject lasts for three hours.

FIRST STAGE, OR ELEMENTARY EXAMINATION.

You are not permitted to attempt more than *eight* questions.

You may select only *two* in Magnetism, *three* in Frictional Electricity, and *three* in Voltaic Electricity.

The value attached to each question is the same.

Magnetism.

1. What is the magnetic condition of a bar of soft iron held horizontally above, and parallel to, a permanent magnet of the same size, resting horizontally on a table?

2. A bar magnet is laid on a table with its N. end projecting over the edge. A soft iron ball clings to the under side of the projecting end. State and explain what happens when the S. pole of a second magnet is brought above and near to the N. pole of the first.

3. You have three equal bar magnets without keepers. How would you arrange them so that, when not in use, they might preserve their magnetism? Give a sketch.

4. If you wish to support a uniform bar magnet horizontally on a pivot, how is it that the pivot must be placed nearer to one end than to the other? To which end must it be nearest in this country?

Frictional Electricity.

5. A piece of brass tube held in the hand and struck with a cat's skin shows no electricity when it is made to touch an electroscope. How would you prove experimentally that it was really electrified when so struck?

6. How is it that in damp weather an ordinary plate electrical machine will not work well?

7. In the common plate or cylinder eletrical machine the conductor is of rounded shape at all parts except where it comes nearest to the plate or cylinder, but here it is provided with sharp projecting points. What reason is there for this arrangement?

8. A little pith ball rests on a brass plate provided with a glass handle. The two are placed on a cake of resin which has been rubbed with a cat's skin. When the plate is touched

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by the finger and then lifted by the handle the pith ball jumps off the plate. Why?

9. A deep metal pot, positively electrified, stands on a glass stem. A metal ball hung by a silk thread is put in contact with a gold-leaf electroscope after being made to touch—

(a) first the *inside* and then the *outside* of the pot; or

(b) first the *outside* and then the *inside* of the pot.

State and explain the effect on the electroscope in each case.

Voltaic Electricity.

10. How would you prove that the electrical difference between the prime conductor and the rubber of an electrical machine is of the same kind as that between the copper and zinc ends of the battery?

11. How is it that if the poles of a battery are connected by a long thin wire, the battery does not get so hot as when a short thick wire is used?

12. A rod of soft iron is placed upright on a table. Its upper end is surrounded by a coil of insulated wire which does not touch the rod. When a strong current goes through the wire, the iron rises in the coil. Explain how.

13. You have access to the terminal wires, made of copper, of a hidden battery. Explain how you would tell which wire was connected with the zinc and which with the platinum pole of the battery by observing what happens when the ends of the wires are dipped at the same time into the same vessel containing a solution of sulphate of copper (cupric sulphate).

14. How could you temporarily stop or weaken a current in a wire without disconnecting it from the battery, by means of the motion of another wire through which a current is passing?

SECOND STAGE, OR ADVANCED EXAMINATION.

You are not permitted to attempt more than *eight* questions.

You may only select *two* in Magnetism, *three* in Frictional Electricity, and *three* in Voltaic Electricity.

The value attached to each question is the same.

Magnetism.

21. A magnet is balanced on a fine point so that it can turn freely in a horizontal plane. When disturbed from its position of equilibrium it will oscillate from side to side. Upon what does the time depend, taken by the magnet, to make one swing?

22. What is meant by the "magnetic moment" of a magnet? Describe a method of finding by experiment the proportion which the magnetic moment of one magnet bears to that of another.

23. Two soft-iron rods are placed vertically, one east and the other west of the centre of a compass needle—the lower end of the rod on the east and the upper end of the rod on the west being level with the compass. Describe and explain the effect on the compass.

24. A mariner's compass is placed on a table, and a bar magnet is laid on the floor below it, the centre of the bar magnet being straight underneath the centre of the compass needle. When the N-seeking end of the bar magnet is northwards the compass needle, after being disturbed, makes 100 oscillations in 16 minutes. When the N-seeking end is southwards the compass makes 100 oscillations in 12 minutes. When the bar magnet is removed, so that the compass needle oscillates under the influence of the earth alone, how long will it take to make 100 oscillations?

Frictional Electricity.

25. In some forms of the electrometer there is a movable disc surrounded by a wide flat ring in the same plane as the disc. Explain the use of this ring.

26. Water is allowed to escape, drop by drop, from a tube connected with an insulated vessel. The knob of a charged Leyden jar is placed near the end of the tube from which the water drops, so that the water does not touch it. What will be the effect on an electroscope connected with the water vessel? On what does the ultimate electrical condition of the water vessel and electroscope depend?

27. A small insulated metal ball is charged so feebly that it does not affect an electroscope. Describe and explain any device (such as the "Doubler" or "Replenisher"), whereby the charge on the ball can be made to give rise to a larger charge.

28. One pole of a battery of many cells is earth-connected, and a long insulated wire projects from the other end. Two insulated metal balls, of 1 inch and 5 inch diameter respectively, are put one after the other in contact with the end of the insulated projecting wire. What are the comparative quantities and densities of the electricities on the two balls?

29. Two Leyden jars, charged in the ordinary way, are held, one in each hand, by the outer coatings. What takes place when the knob of the one is made to touch the outer coating of the other, and what is the subsequent condition of each jar?

Voltaic Electricity.

30. What do you understand by the polarisation of the platinum plates employed as electrodes in a voltameter? How would you show experimentally in which direction the polarisation acts?

31. The terminals of a battery formed of seven Daniell cells in series are joined by a wire 35 feet long. One binding screw of a galvanometer is joined by a wire to the copper of the third cell (reckoned from the copper end). With what point of the 35 feet wire can the other screw of the galvanometer be connected so that the needle shall not be deflected?

32. A hoop of wire is made to rotate uniformly about a vertical axis. Show the direction and variation in strength of the current generated in it at different periods of its revolution.

33. The resistances of two wires made of the same metal, *a* and *b*, are as 2 to 3. What are the relative amounts of heat developed in the wires—(1) when they are fastened end to end, and the same current passes through them; and (2) when they are arranged in "multiple arc," that is, when each connects the ends of the same battery so that the battery current is divided between them?

34. A single Grove cell is joined up in circuit with a voltameter in which acidulated water is decomposed between platinum electrodes, and the strength of the current is noted. On connecting a second Grove cell in series with the first, the strength of the current becomes considerably more than twice as great as before. Explain this.

HONOURS EXAMINATION.

Full marks can only be got by answering all the questions.

The value attached to each question is the same.

41. Describe and explain a method of determining experimentally, in absolute measure, the quantity of electricity produced by each revolution of an electrical machine.

42. Describe a method of measuring accurately the resistance of a thermo-electric pile, showing how you would guard against errors arising from the heating or cooling of the junctions by the passage of the testing current.

43. A copper disc which can turn about a horizontal axis, dips by the lowest part of its circumference into mercury, and the poles of a horse-shoe magnet are placed, one on each side of the disc, near its lowest part. On connecting the poles of a voltaic battery, one with the centre of the disc and the other with the mercury into which it dips, the disc revolves. If it were possible entirely to get rid of friction or other mechanical hindrances to the motion of the disc, show what effect this would have on the speed of rotation and on the strength of the current of the battery.

44. You have an electrical condenser, one or more galvanic cells of known electromotive force, a seconds' pendulum (or other accurate timekeeper), and a galvonometer, with a rather massive needle, and wound with a great length of fine wire. How could the electrical capacity of the condenser be determined with these apparatus?

45. In addition to the apparatus mentioned in the last question, you have two coils of insulated wire and a tangent-galvanometer. How could you determine the co-efficient of mutual induction of the two coils?

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THE ELECTRICIAN.

TO CORRESPONDENTS.

All letters intended for insertion in THE ELECTRICIAN, *or containing questions, must be accompanied by the name and address of the writer, not necessarily for publication, but as a proof of good faith. No notice whatever will be taken of anonymous communications.*

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J. G.—*Will write you.*

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THE STRIKE OF AMERICAN TELEGRAPHISTS.

Either from lack of sympathy or want of information the American correspondents of the English newspapers have kept us in the dark concerning the formidable movement which resulted in a strike of several thousand telegraph operators one day last week. On Tuesday we were apprised for the first time that a strike was imminent, and on Thursday it actually commenced. By Friday evening, apparently in accordance with preconcerted arrangements, the rebellion had spread from the empire city to Boston, to Philadelphia, to Chicago and Cincinatti; thence farther north and west, and included many, if not most, of the principal telegraph centres of the States. If the statistics of the strike are to be relied upon, it must also have extended to less important places, and this with extraordinary rapidity, for the signal whistle which made some three hundred and sixty telegraphers throw up their work at noon on Thursday seems to have reached about nine thousand willing ears by Friday night, all ready and prompt to obey the call. It is impossible to suppose that the event could have been planned and brought to issue as suddenly as the newspaper correspondents would have us suppose. All we are told is that on Tuesday the clerks demanded an increase of 15 per cent. on their wages and a reduction of one hour in their day's work; that the company, or companies, referred these claims to a committee; that this mode of consideration was not to the liking of the delegates representing the telegraphers, and that some scoffing remarks of Mr. Eckert, a representative of the Western Union Company, precipitated matters, so that on Thursday—that is to say, on the second day after the demands were submitted—the delegates resorted to the final measure of a general turn-out. The incredible precipitancy of the proceedings leaves a good deal to be explained, and by the time these lines are in print probably we shall be favoured with fuller particulars of previous negotiations to account for an ultimatum so emphatic in its tone and so unreasonably hasty in its execution.

Until we are in possession of more trustworthy details we can offer no opinion on the merits of the immediate question in dispute; and, indeed, at our remote distance, any remarks we might offer, even if we were better informed, would probably do injustice to one or other of the parties concerned. Fifteen per cent. increase on wages initially so high as fifty dollars a month, which is said to be the average rate of pay in the States, seems to us on this side of the water a very big increase indeed, to say nothing of the demand for one hour's less work per diem, swelling the demand, practically, to 25 per cent., or perhaps more. On the other hand, it is no sort of answer to the demand to say, as the Western Union is reported to have said, that it would cost the company a million and a-half dollars a year to accede to the demands of its clerks. The significance of these figures wholly depends on the size of the company, its revenue, its profits, its obligations, and the amount, if any, of extra work it has imposed on its servants since it made its first bargain with them. We suspect that something in the changed relations between the employers and employed, resulting from the gigantic amalgamation schemes in which the Western Union has been engaged during recent years, is at the bottom of the quarrel, otherwise demands so seemingly extravagant and so peremptory would hardly have been made. Both parties incur grave responsibility, perhaps equally; but, whilst it is difficult to attribute responsibility to a miscellaneous crowd of private individuals, it is easy to fix it on a single person or a corporate company. Possibly this is the chief reason the Press on the spot is almost unanimous in blaming the Western Union, and sympathising with the "strikers." At all events, no other explanation is forthcoming, and it is fair to assume that, either the company is made a scapegoat because there is none other handy, or else the animal is particularly obnoxious to begin with. The Western Union has evidently not gained in popularity with its huge gain in power. From every quarter it is solemnly lectured or angrily denounced, the one exception being a newspaper said to be the organ of the gentleman who enjoys the proud but onerous distinction of being the "virtual proprietor" of the offending company. This paper, the *Tribune*, calls the brotherhood—meaning the combined telegraphists—"a secret, oath-bound organisation." We should like to know what the brotherhood calls Mr. Jay Gould.

In one respect this strike in the States, though far more extensive than anything of the kind perpetrated in this country, closely resembles the strike of 1871, and the threatened repetition of it ten years later. The immediate cause of the earlier strike was, if we recollect rightly, the delay in fixing the salaries of the men under the new administration, but the proximate cause was the amalgamation of all the companies into one, and the consequent bringing together large bodies of men who had previously been apart. Combination was for the first time possible, because for the first time combination became effective. The sort of co-operation

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required for a strike was difficult and had never been attempted while the several administrations remained independent and even hostile; but the moment they came together their *employés* were united, and their capacity for a combined assault upon the pocket of their employer was at once developed. They succeeded at that time in forcing the hands of their new masters, and more recently they were able to extort fresh concessions by merely threatening to use their power. This is a bare statement of fact, and has nothing to do with the merits of the claims one way or the other. Similarly in America the servants have become formidable in proportion as their master has grown inflated. A lot of separate concerns have been swallowed up or assimilated by one of them more ambitious or more speculative than the rest, with the result that it has got more than it bargained for. If the horse was ever a two-legged creature it no doubt repented its tendency to develop into a quadruped directly somebody got on its back and applied the whip. Perhaps Mr. Jay Gould is experiencing a similar sensation now that he sees his ten thousand subjects refusing to work for him, and blowing a whistle instead.

But the power to harass a master is not the only inconvenience arising out of amalgamation of services on a large scale; there is a positive tendency to increase the disposition to harass him, or, at all events, all the old checks of the moral sort, as well as the practical one before referred to, have been removed. *Esprit de corps* always exists in competing services; it exists in different regiments under one general, it exists even for a company as such, the East India Company and many other ancient corporations being cases in point. Some of these were gigantic monopolies; yet that did not in the least detract from the zeal, devotion, and sturdy fidelity of their servants. But when a State, or, as in the case before us, a big company, takes to reorganising things by casting them all into one mould, it must be content to see such qualities as pride in the service, *esprit de corps*, and the like, depart for ever. It strips the badge from the collar, it hides the regimental colours, and issues a uniform of grey. All healthy rivalry, all the recollections of past achievements, all attachment to ruling heads have vanished, and their place is taken by self-seeking calculations as to what can be got in return for what has been lost. And this is obviously more likely to ensue where the whole proceeding has been one of money. To put it plainly, these men and women on strike in the States are asking for their share of the booty. If a great deal of money has been bagged over the transactions which have made the Western Union Telegraph Company what it now is, an equally great deal has been lost; but the operators are not likely to draw refined distinctions in favour of those who have lost money; they probably think they know pretty certainly who has won, and at a given signal they insist on pocketing some of the winnings themselves. The demand may be unreasonable, it may be even immoral, but nobody will say it is surprising. If it be true, as is commonly asserted, that one man virtually owns the Western Union system—and it certainly is true that one man is its master—then a great opportunity offers itself for him to show the stuff he is made of. Devotion to a single individual is often a more powerful factor in disputes of this sort than fidelity to a body of men calling themselves a company. If Mr. Jay Gould can command or enlist this devotion, it is not too late even now to exercise his influence, and bring the rebels back to their allegience. If not, he will be extremely fortunate if he fights his battle, as it is said he intends to do, at the cost of only a million dollars. At present there appears to prevail between him and his late *employés* pretty much the same sort of sympathy and goodwill as may be supposed to exist between the captain of a slave ship and the niggers down in the hold.

CORRESPONDENCE.

"PROFESSOR FORBES'S" ACCUMULATOR.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In your issue of this date I see another reference to "Professor Forbes's accumulator." I am not aware of the existence of any other Professor Forbes in this country besides myself, and the continued use by a certain company of this name for their accumulator has already given me much annoyance. For the present I content myself by asking you kindly to publish the fact that I am not the inventor of any accumulator, and that no company has the right to use my name in this connection.—Yours, &c.,

GEORGE FORBES.

34, Great George-street, Westminster,
July 21, 1883.

OHM'S LAW. PROFESSOR MINCHIN'S COROLLARY. *ERRATUM.* ARCHBISHOPS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Perhaps Professor Minchin's corollary will be made intelligible to non-mathematicians by first letting E.M.F. and current change places. Thus, if three E.M.F.'s at right angles produce currents in one plane, the current corresponding to *any* E.M.F. will be in that plane. For, by the simple proportionality involved in Ohm's law, if the three E.M.F.'s are altered in any ratio, the currents are similarly altered without changing direction. Their resultant is in the plane, and the resultant of the three E.M.F.'s may be any E.M.F. This case may be imagined by having no conductivity in a certain direction, when, of course, with symmetry, the current can be only in the perpendicular plane.

Now let the resistance be *nil* in a certain direction, then, with symmetry, whatever be the direction of the current, the E.M.F. must be in the perpendicular plane. The ellipsoid of E.M.F. corresponding to the sphere of current becomes flattened, and ultimately an elliptic disc as the resistance in a certain direction is indefinitely decreased. But why, it may be asked, should we not, even in this extreme case, impress the E.M.F. arbitrarily in any direction we please, and not be confined to one plane? We may do so, but the general equations refer to the E.M.F.'s required to *maintain* currents. No E.M.F. is needed to keep up a current against no resistance. The current perpendicular to the plane is therefore quite arbitrary, and is without supporting E.M.F. Whatever E.M.F. there may be impressed in the direction of no resistance would be otherwise employed than in maintaining current, as will be seen in the continuation of "Current Energy."

Another extreme case is that in which the current is confined to one direction, not one plane, for E.M.F. in any direction; and similarly there may be E.M.F. in one direction and current in any.

Perhaps to spare my feelings, Professor Minchin has not pointed out an absurdity, which I therefore now do myself. *Erratum*, p. 198, 2nd column, 9th line from end, *dele* from "which" to end of sentence, as the least thought will show it to be nonsense. It was written without thought. Now I come to think of it, the mental stagnation was produced by an overdose of M – k, proving life to be not worth living. Quite recovered next day, under counteracting influence of "most excellent" green peas at 6d. a peck (raised to 8d. by the mercenary vendor on hearing them praised).

As to Professor Minchin's remarks on the archbishop, I must say that I do not think them quite respectful, I really do not. Archbishops are privileged. They have reached the

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highest summit of respectability in an ultra-respectable country, to say nothing of their powers of intercession to turn a drought into damp. I should hardly dare to criticise an archbishop, not if he fired off a whole volley of electroscopes and Leyden jars in defence of the Faith. I had the great pleasure of *seeing* a live archbishop this summer, the new one, entering Westminster Hall, no doubt on his way to his parliamentary duties, perhaps to keep men from marrying their deceased wives' sisters, and a nicer looking man for an archbishop I could not conceive. He wore the most *delightful* pair of trousers, buttoned tight all the way up the calves, and my respect for the cloth, always great, was much enhanced thereby. His appearance at the door and dignified entrance will not be soon forgotten.—Yours, &c.,

OLIVER HEAVISIDE.

"SHEEPISH."

TO THE EDITOR OF THE ELECTRICIAN.

SIR: *Apropos* of one of your notes entitled "Sheepish," in this week's issue, I should be glad if you would give publicity to the following, as illustrating the flagrant injustice which is sometimes done through reporters writing on subjects of which they have little if any knowledge.

In the description of the various systems of electric lighting in the *Daily Telegraph*, June 27th last, the following sentence occurred:—"In the conservatory are four large Siemens lamps, of 5,000 candle-power each, arranged in parallel arc, an interesting result, which was deemed impossible a very few months ago."

Many of your readers, Sir, will doubtless be aware that the Gülcher system is essentially one of parallel arc, and that so far back as 1881 Mr. Gülcher exhibited at the Paris Exhibition eight 2,300 candle-power arc lamps in multiple or parallel arc from one of his machines. To the general public, however, this may not be so well known, and consequently on the day of issue a letter was addressed to the editor of the *Telegraph* pointing out the mistake, and setting forth the facts already stated above. A week passed, however, and no notice was taken, when again we wrote, but still no correction appeared. As a last resource, however, we sent the correspondence for publication, offering to pay for same, but this was refused.

There is no question but that the editor could have satisfied himself as to the justice or otherwise of our claim had he felt so inclined. Instead of this, however, the whole matter appears to have been ignored, and an injurious misstatement allowed to pass into history, sooner than own that an incompetent reporter, left to the mercy of his informants, had been sent to supply the public with detail of so important a matter as electric lighting.—Yours, &c.,

THOS. H. HARRISON, Manager of the Gülcher Electric Light and Power Co.

MEDICAL ELECTRICITY.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: The letter in your issue of the 21st appears to me so liable to discourage some humble efforts at coil construction and application that I cannot refrain from reiterating the statement that I have actually seen and felt great benefits from apparatus far less costly and cumbersome than those therein recommended.

The electric bath is, no doubt, the *best* and *quickest* remedy for many complaints. Yet it is only a question of *degree*.

The currents do not necessarily penetrate to the deepest tissues, because the skin is quite wet, though it does to a greater extent than when only moist. There are, however, *induced* currents which do penetrate these tissues. But since a very large proportion of the capillaries lie near the surface a vast amount of action may take place without the internal organs being actually the paths of the currents.

Suppose a coil wound with two or three pounds of No. 22 or 24 wire, and worked with two or three cells of any ordinary battery, and the skin kept moist with a sponge at the parts where the electrodes are applied.

This would suit those who prefer the exercise of a little patience and constant treatment (for, say an hour a day) to making a large outlay.

Some wonderful cures the electric bath has wrought. It has also been known to kill.

The subject is one of great interest, and I, doubtless with many of your readers, am much obliged to Mr. Kent for giving us the benefit of his valuable experience.—Yours, &c.,

A. W. BENNETT.

THE LAW OF GRAVITATION.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In your last week's issue, page 223, Mr. J. T. Sprague says:—"There are actual forces having real existence, such as the various attractions, of which we may take gravitation as the type; these are, so to speak, self-existent—we know not their causes." I would suggest for consideration the possibility of gravitation being simply a case of electro-magnetic attraction, the earth being the electro-magnet.—Yours, &c., JOHN RONALD SHEARER, A.C.A.

10, Basinghall-street, London, E.C.

THE SIPHON RECORDER.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Your correspondent "W. B.," of Zante (see *Electrician*, p. 179), is wrong in stating that since the publication of Messrs. Cuff and Ewing's pamphlet on this fine instrument in 1873 and 1876 nothing further has appeared in England. On the contrary, a very full and illustrated account of the latest form of recorder, as exhibited at Paris in 1881, appeared in *Engineering* for January 13, 1882. M. Ternant, in fact, is indebted to that account for his illustration.—Yours, &c., J. MUNRO.

SHORT MEMOIR OF EDWARD DAVY, M.R.C.S., M.S.A.

BY HENRY DAVY, M.D. (LOND.), M.R.C.P., PHYSICIAN TO THE DEVON AND EXETER HOSPITAL.

The following short biographical sketch of my uncle has been written by me at the request of Mr. Fahie in order to complete the history of the MSS. which he has lately published.

Edward Davy's family originally settled near the coast in Dorsetshire, where about the year 1616 they were living on their own estates. Unfortunately they took an active part against the king in the Monmouth Rebellion, and when Judge Jefferys commenced the "Bloody Assize" they found it convenient to migrate into Devonshire, where they commenced life afresh, mostly pursuing the occupation of farmers. His grandfather was a farmer, partly owning and partly renting his estates in the neighbourhood of Exeter, while his father was Thomas Davy, who resided at Ottery St. Mary, and had an extensive medical practice in Ottery and the neighbourhood. Thomas Davy was educated at Ottery and Guy's Hospital, at the latter being a pupil of Sir Astley Cooper, but from the time he left London it is much to be questioned whether he was ever out of Devonshire more than five or six times in his life.

Edward Davy was born in 1806, and was educated at a school kept by his maternal uncle, Mr. Bontflower, in Tower-street, London. Subsequently he was apprenticed to Mr. Wheeler, house surgeon at St. Bartholomew's Hospital, and about the year 1828 he became a "Member of the Royal College of Surgeons," and soon after a "Member of the Society of Apothecaries." Shortly after this he bought a business at 390, Strand. I have always heard it stated that some eight or nine hundred pounds were advanced by his father to buy a medical practice, but that he was taken in, and found that

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the so-called practice was that of a dispensing chemist. However this may be, he soon began to trade as an operative chemist, under the name of Davy and Co., and in 1836 he published a small work termed "Experimental Guide to Chemistry," at the end of which is a catalogue of the instruments, &c., supplied by his firm. This guide book might even now serve as a useful text-book for a beginner in experimental work, whilst in the catalogue at the end he mentions several of his original modifications of instruments, such as "Davy's Blow-pipe," "Davy's Improved Mercurial Trough," &c., proving how completely he had given himself up to his favourite pursuit.

About this time, 1835, he invented and patented a cement for mending broken china and glass, which for many years brought him in a small income, and was well known as "Davy's Diamond Cement," and it was during these years that he first commenced to experiment on the "Electric Telegraph," but this part of his history up to the time of his leaving England has already been told by Mr. Fahie. One question which will be asked by all the readers of Mr. Fahie's narrative is: Why did Edward Davy fail in his attempt to get his system of telegraphy adopted? It seems certain that at the time of his leaving England his system was in a more perfect state than that of Cooke and Wheatstone. It is seen, too, that Edward Davy was and had been negotiating with some of the leading engineers, railway companies, and railway directors, and that many of them had almost promised to adopt his system. Why, then, did he fail? Chiefly because he left England just at the wrong moment. Into the reasons of his leaving England there is no occasion to enter. Suffice it to say he had been contemplating doing so all through the end of 1837 and 1838, and that his reasons were entirely of a private kind. But in leaving England when he did he struck the death-blow to all his hopes; and had he remained in England his system, as Mr. Fahie says, would probably have been adopted. It is important to note that he himself did not realise the fact that his leaving England would ruin his invention, and that had he realised his true position he would probably have stayed on until his negotiations with the railway companies were concluded. In a letter to his father early in 1839 in which he announces his final decision to leave he says:—

"I have perfected, as far as I can, secured, and made public the telegraph. What remains, *i.e.*, to make the bargain with the companies when they are ready and willing, can be managed by an agent or attorney as well as if I were present."

How entirely wrong this opinion was subsequent events soon proved, for the directors, having no one to deal with who thoroughly understood his instruments, adopted that of his rivals, Cooke and Wheatstone.

But other causes greatly contributed to his failure. The first is brought out in the sketch I have given of his family. His father was, for his day, a well qualified medical man, but he was quite destitute of any scientific training, whilst his close residence in Devonshire had prevented his seeing the direction in which the thought of the day was moving. To most people in 1837 the idea even of a railway was new; and when Edward Davy talked of "*sending messages along a wire for hundreds of miles*," when he predicted the use of "marine cables," hinted at the "*telephone*," and prophesied that the "*Government would adopt the telegraph as part of their postal system*," it is excusable that his father should regard him as a visionary, and should tell him that his plans were all "*moonshine*." When, too, he found that he had to pay for this "*moonshine*" by constant remittances one can easily forgive his anxiety that his son should go back to the regular practice of his profession; especially when to his old-fashioned ideas it was almost a disgrace for a medical man to have a son an operative chemist. Not only did his father discourage Edward Davy in his pursuits, but he took no pains to bring his invention to the notice of many influential friends, who might have helped him in his endeavours to make it known to the public.

From Mr. Fahie's narrative, it seems evident that had any well-known firm taken up the invention, and pressed its advantages on the public, the railway directors would have adopted it. Thomas Davy's brother was a merchant of wide local reputation, who at one time had been one of the Government's largest contractors for building wooden frigates, while his nephew was a rising partner in one of the best-known and largest mercantile houses of the day (Anthony Gibbs and Co.), and yet neither of these was in the least made acquainted with the patent of the electric telegraph. This was the more deplorable since Edward Davy was evidently unfortunate in his choice of business men. Repeatedly in his letters to his father he states that neither Mr. P— nor Captain B— nor Mr. B— are assisting him as he should wish, and had he been assisted by any energetic man of business it is probable that Mr. Fahie's history would have ended very differently. Like most other geniuses Edward Davy had no marked business capacity; he could invent an original machine, he was not able to hold his own with farseeing men of the world. He had no friend to advise him, and he was unfortunate in the agents whose assistance he obtained. Had he offered 50 per cent. of his eventual gains he would have attracted the service of men of acknowledged position. As it was his offer of 10 per cent. did not attract these, and even when he offered 25 per cent. to Mr. P., the latter did not keep his part of the undertaking, so that the compact broke through. After careful perusal of the MSS., I am convinced that Edward Davy did everything in his own power to make his invention succeed; he failed because he had little business capacity and his father's line of action prevented his getting even friendly advice from quarters where it might have been obtained. But the questions will be asked, Why has Edward Davy allowed his claims as a pioneer in telegraphy to be so completely ignored? And why have not his family published these MSS. before?

The answer to the latter question is simple. I very much doubt if the family knew anything about these MSS. They were collected and labelled by another uncle of mine long since dead, and it was only after the death of my father last year that they fell into my hands, after having narrowly escaped being burned as rubbish. They came into my possession last March, and when by chance Mr. Fahie in May wrote to ask me for information as to my uncle, I readily placed them at his disposal, only stipulating that, as he was quite a stranger to me, he should publish nothing without my permission. Until I saw his annotations I was not aware of the extent of Edward Davy's inventions, and I am quite sure my father had no idea as to the value of these MSS., for his training as a solicitor had not taught him any science.

I do not know why Edward Davy himself allowed his claims to be ignored. Probably he did not know that these MSS. had been preserved, and without them he would have no proof with which to support his claims. After leaving England in 1839 he threw all his energies into the colonial life he had adopted. His letters to his father, mother, and brothers are full of references to this new mode of life. He busied himself in acclimatising trees, grasses, &c., the seeds of which he obtained from England. His leisure he filled up with writing newspaper articles on hygiene and other subjects. He also pursued his favourite subject, chemistry, and invented and patented a "plan for saving fuel during the process of smelting ores." For many years he was assayer to the Mint at Melbourne, while for the past twenty-five years he has carried on a medical practice, more latterly in partnership with one of his sons. In this busy colonial life he has, no doubt, found more happiness than in brooding over his disappointments. Only in one letter to his family do I find any reference to the telegraph. Writing to one of his sisters in 1841, after saying that a storm is preventing him from going to sleep, he adds:—"I shall therefore enter into some conversation with you, although, from there being no electro telegraph, it may be five months ere my voice reaches you," and as Mr. Fahie says he will be quite as surprised as any one at finding that his labours of forty years age have now been made public.

Mr. Fahie concludes the narrative of Edward Davy's inventions and negotiations by terming it a magnificent failure, and I think no one will deny this who has read how nearly he obtained complete success. It was, however, only a failure

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as far as he, himself, was concerned. His labours were, in reality, most useful. His experiments in Regent's Park, his exhibition of his instrument in Exeter Hall, brought electric telegraphy before the public in a way which was done by no other person. His correspondence with, and the constant advocacy of his invention to such men as Brunel, Fox, and Easthope forced the electric telegraph on their notice with a double force, and, no doubt, did much to cause its early adoption. I do not here enter into the question as to how far his ideas were adopted by others. It is certain that, with a strange lack of business-like foresight, he exhibited his machine before it was patented, and that his exhibition was visited by Cooke, Wheatstone, &c. Probably his work has assisted many of his successors in working out improvements; but quite apart from this his labours were useful, and are well worthy of recognition. It is interesting to note that he spent some thousands in experimenting and making these experiments public. Mr. Fahie has shown me a letter printed in the *Mechanic* from the late Dr. Cornish, vicar of Ottery St. Mary. This letter says Edward Davy's family spent thirty thousand pounds on the electric telegraph. I do not know whether there is a misprint here, but if the thirty be divided by ten I think the resulting three thousand would be more near the mark. It is also interesting to note that Edward Davy is still alive, and well appreciated by his fellow townsmen in his colonial home. Almost the last paper I got from him contained an account of an entertainment given in his honour, at which, he having refused any more substantial acknowledgement, he was presented with an illuminated address in recognition of his having been for many years a magistrate and on three occasions mayor of his town, and for having for twenty-five years gratuitously held the office of medical officer of health to the district.

It is to me a satisfaction that these MSS. have come to light during his life time. He is now seventy-seven years of age, and for the past forty years his claims have been quite ignored. He, I am sure, would be the last to claim any position which was undeserved, but it cannot but be a pleasure to him if he sees the real value of his work recognised, his name rescued from an unmerited oblivion, and placed in its proper position as one of the very first pioneers of electric telegraphy.

LITERATURE.

Philipp Reis: Inventor of the Telephone. A Biographical Sketch, with Documentary Testimony, Translations of the Original Papers of the Inventor, and Contemporary Publications, by Professor SILVANUS P. THOMPSON. [E. and F. N. Spon.]

We should not wish for a better advocate in a good cause than Professor Thompson, and in the case of Reis he has had a good cause, and his labour has evidently been a labour of love. There is no doubt from the evidence set forth in this book that Reis had done more and thought further than most of us believed till the efforts of Professor Thompson made people consider the claims of Reis. It is probably well understood that this journal is exceedingly jealous in the matter of appraising claims, as the tendency nowadays is to attempt to detract from the honour due to the successful worker. The claims of Reis have been more than once discussed with more or less leaning against them, but we are glad to acknowledge that we can, after due consideration of the evidence put forward, heartily agree with Professor Thompson that Reis "was in advance of his time, that the world was unprepared to receive or use the splendid discovery which he freely gave to it," but "that was not his fault; nor does neglect or apathy make him in one single degree the less entitled to the credit of his inventions."

We shall not attempt now to critically examine the contents of the book, but rather to indicate them, using as far as possible the words of the book, hoping that this course will influence readers to obtain the work for themselves. Johann Philipp Reis was born January 7, 1834, at Glenhausen. His early education was at the common school, but at the age of eleven, one year after the death of his father, he was sent to Garnier's Institute at Friedrichsdorf. In 1850 he became an apprentice in a colour establishment, but continued his studies. Several friends formed a mutual education society, and Reis became an amateur teacher. He found his vocation. While at Frankfort, in 1851, he joined the Physical Society of that city. In 1858 he returned to Friedrichsdorf as a teacher in the institute. He was actively employed in experimental work, and in 1859 sent a paper "On the Radiation of Electricity" to Professor Poggendorff, who, however, refused it for the *Annalen.* Afterwards he met with another rebuff from Professor Poggendorff, who in 1862 refused a memoir on the telephone. "Reis," says Professor Thompson, "who was convinced that the rejection was because he was 'only a poor schoolmaster,' was more deeply pained than ever." Lectures by himself and others made his invention known, and telephones became an article of commerce. Still, the invention was looked upon as a scientific toy. There was no far-sighted capitalist to take the inventor by the hand, nor had Reis the physical stamina to put his work forward in the face of an inert public. In 1873 he disposed of all his instruments and tools to the Garnier Institute. "To Herr Garnier he made the remark that he had shown the world the way to a great invention, which must now be left to others to develop." In December, 1873, he was laid upon a sick bed, and died of consumption on Jan. 14, 1874. The Physical Society of Frankfort in 1878 erected a monument to the memory of their former colleague.

We will not now deal with the evidence that Professor Thompson has collected, but merely quote the last paragraphs of the book, expressing our full accordance with the remarks made therein:—

"If then," says Professor Thompson, "mere mechanical imperfections do not make an invention any the less a true invention capable of legal recognition, it would be dishonest to the last degree to deny to Philipp Reis the honour of his invention, of which he honestly and openly stated both the successes and the imperfections. He told the world what he aimed at, and in what measure success had crowned his aims. His claim to be the inventor of the telephone he considered to be justified by that measure of success. If he was so far in advance of his time that the world was unprepared to receive or use the splendid discovery which he gave freely to it, that was not his fault; nor does neglect or apathy make him in one single degree the less entitled to the credit of his inventions. *Tulit alter honores* has not unfrequently been truly said concerning the men of genius who have had the misfortune to live in advance of the age.

"But posterity does not let the names of such truly great ones perish in the dust. The inventor of the telephone will be remembered and honoured in the coming if not in the present age."

PRACTICAL TELEPHONY.

(CONTINUED FROM PAGE 238.)

THE EXCHANGE.—Before laying out a switch room attention should be directed to the fact that telephonic communication progresses very rapidly, and arrangements that at the present may seem ample may in the course of six months prove quite inadequate to the business; therefore so plan your room that, according to the description of apparatus decided upon, it will admit of the greatest number of subscribers being connected to the system. If properly planned the actual apparatus required at first need only be set up. Subsequently set after set may be added without the least confusion or interference with the existing service; above all things, if you have a fairly good system do not change it for another. You understand its faults and its virtues, so do not always be inclined to change for what may prove to be worse than the one you have. In making a choice of a system the following points must be kept in mind:—1st. That each operator may have the largest number of lines under complete control without being overtaxed. 2. That the connections from board to board in the same office be as simple as possible. 3. That ample provision is made for connecting a considerable number of sub-

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scribers from board to board to avoid a block. 4. That the contacts are firm and good. 5. That the annunciators are strongly made, the coils well protected, and that the connections to line and switch-board can be easily and surely made. 6. That the apparatus is as compact as possible, without in any way sacrificing efficiency in manipulation. 7. That easy access can be had to all the connections for inspection at any time without interrupting the operator. 8. That the simplest apparatus that will do the required work is preferable to a showy complicated one, apart from the reduced price that the more simple one will cost. The resistance of the annunciator coils should be about 24 ohms.

THE OPERATING TABLE.—The form and connections in common use will be shown next week. The key is double; the left-hand key is for closing the local circuit, and has a spring contact underneath to ensure a more permanent contact, the imperceptible tremor of the operator's fingers making and breaking contact causing a break in the sentence being transmitted. The under spring contact follows the motion of the key to a limited extent, thus preventing the break in the transmission. But microphonic action will still occur unless the contact is firmly made; the key should therefore be as weak as possible, consistent with fairly breaking the contact upon removal of the pressure, so as to reduce the strain upon the fingers. The right-hand key is for "ringing up" a subscriber, and may be more stiffly adjusted. This form of key is used when all the subscribers are provided with bells worked by a battery. When they are mixed (*i.e.*, some battery instruments and some magneto), a treble key is used, the left-hand for speaking, the centre for calling subscribers who have battery instruments, the right-hand key for calling subscribers who have magneto instruments. The magneto generator can be supplied to each table, or one can be kept continuously revolving by means of a small Thirlmere water motor and branches led from one of its terminals to every table, the remaining terminal to earth connections shown in Fig. 44. Owing to the increasing use of long trunk lines between towns a third form of table key is sometimes required, having four springs, the first three being used as mentioned above, and the fourth being connected with the larger battery, perhaps 36 cells or more used for "ringing up" the distant switch room. With regard to the number of switch tables required, that must be determined by the amount of business, but the smallest exchanges should not have less than two. Owing to the number of cells required for "ringing up" in larger exchanges, it is advisable to employ a magneto generator driven by a small water motor. If the subscribers have bells made for battery use the magneto should be constructed to give a current constant in one direction.

THE SWITCH-BOARD (SLIPPER SYSTEM).—In exchanges in the smaller towns, in which, although serving a considerable number of subscribers, the calls are fewer in number than in the large centres of business operations in London, the annunciator board and switch-board may be placed together and attended to by the head operator, the other operators taking one table each. In large centres, however, as in London, the calls are so frequent (at times the drops come down in a shower, as though the board had been violently shaken) that an operator could not attend to both annunciator and switch-board; they are therefore placed a short distance apart, or if placed together, as in the plug board system, only a very limited number of subscribers, in some cases 24, can be allotted to each operator, who in this case has also a table key and transmitter, and the operating tables are not required.

SLIPPER SPRINGS AND JACKS.—If fitted with a slipper switch-board, a number of jacks joined in pairs by means of a flexible conducting cord are necessary. Two sets should be provided, having different colour cords. One set should be in use one day, the other the next, the spare set being carefully examined to see if there are any signs of the conductors breaking, and, if so, to have them repaired. The cord in the smaller jacks, Fig. 42 (page 237), is fastened by baring the conductor, threading through the milled nut A, tying into a knot, and screwing the nut firmly into its socket at the end of the jack, a piece of small rubber tube being placed on the cord, where it issues from the milled nut A. In the larger jacks, Fig. 45, the whole cord is tied into a knot, first passing it through the ebonite handle A. The conductor is then carefully bared (and this cannot be done too carefully). It is then passed through the double brass socket B, which is then screwed into the ebonite; the conductor is then tied into a knot, and the parts A and B screwed into C, which wedges up the second knot, and makes good electrical contact, the first knot taking the pull it is subjected to in use.

NEVER WITHDRAW THE JACKS BY DRAGGING AT THE CORDS.—Owing to the trouble that will arise unless the cords are very carefully inspected, the writer suggests trying the most flexible copper cord that can be procured, and before fixing the second jack sliding on a length of small rubber tube equal to the distance between the jacks. The cord can then be inspected by sliding the tube on one side. The operator should frequently test the jacks and cords thus: Hold one jack against the knife jack (metal to metal), hold the other jack against the earth terminal of board, now make several contacts with the speaking key, when a loud sound should be heard in the telephone; if only a very feeble sound is heard the cord is broken, that is of course presuming the table itself is in good order. The knife jack, Fig. 46, is attached in the same way to a cord leading to the operating table, and is used to connect that table to the subscribers' line; it differs from the other jack in having no insulated side. The slipper spring, Fig. 47, is that used in some of the larger boards, and is placed directly under the annunciator. The smaller slipper, Fig. 48, is usually made up in sets for 100 or 200 lines. One description will suffice for both. S is the spring firmly attached at the back to the frame; this makes firm contact at its free end with the plate E, which is connected to earth. The connections are as follow: The line is attached to one terminal of the annunciator, the other terminal is connected to the back of the slipper spring by means of the screw shown. Any current therefore arriving from the line passes through the annunciator, dropping

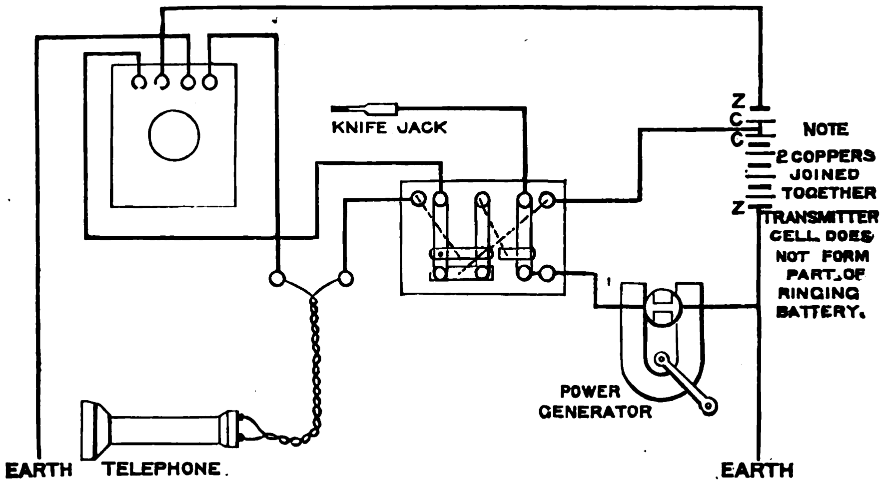

FIG. 44.

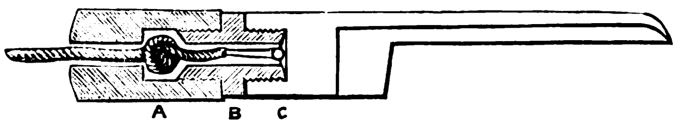

FIG. 45.

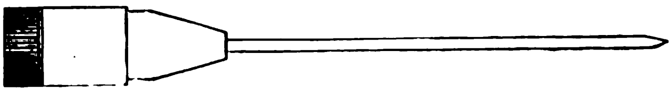

FIG. 46.

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its shutter, thence through spring S to earth plate E. When the jack is inserted it lifts the spring S from the earth plate E, and as the insulated side of the jack is against the earth plate all communication with E is cut off; the line is thus extended into the cord connecting the jacks, and if the second jack is placed under another spring the two subscribers connected with those springs can communicate with each other. Fig. 49 illustrates the last paragraph.

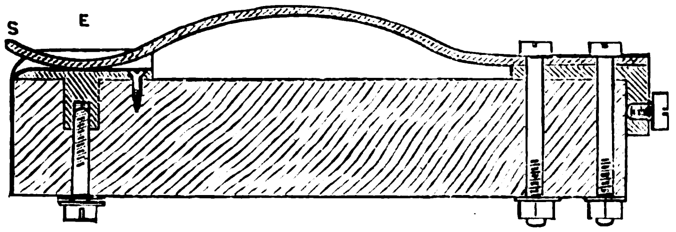

Fig. 47.

Mode of Operating (Slipper Board System).—When a call arrives, the shutter corresponding with that particular line drops. The board operator takes up a double jack cord, inserts one jack under the spring corresponding to the number of the shutter that has dropped, and then between the spring and the jack (so as to be in metallic contact with both) the knife jack of

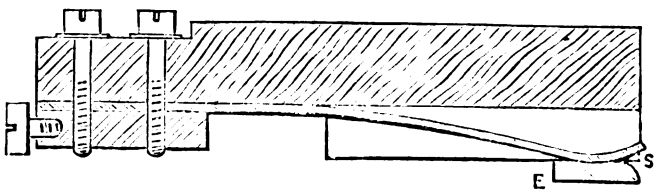

Fig. 48.

one of the tables is inserted. The table operator then rings in reply, and inquires the number of the subscriber with whom the caller wishes to communicate. That being given, the table operator informs the one at the board, the spare jack at the end of the double cord is then inserted under the required spring, and the table operator then rings up until the second subscriber

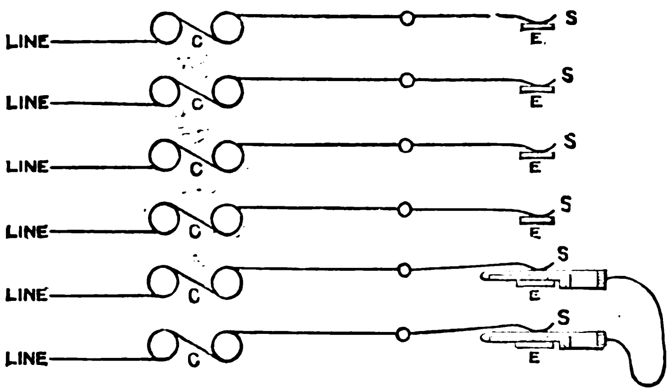

Fig. 49.

replies. The first subscriber, who is probably listening, at once enters into conversation with the other. The shutter should then be closed, and the knife jack withdrawn, because, if left in, the passage to earth through the operator's table much weakens the communication between the subscribers. When the subscribers have finished they are supposed to "ring off," as it is termed,

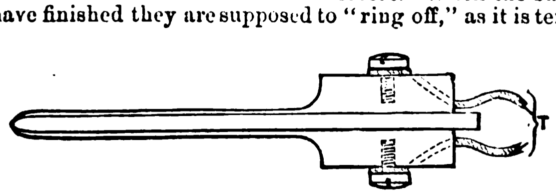

Fig. 50.

by touching their button, which should drop both the annunciators concerned. As a fact, however, the subscribers often forget to "ring off," and if they do remember, if any distance apart, as when speaking through a trunk, there is not sufficient current to drop the shutters. Some means must therefore be adopted to ascertain if the subscribers have finished. This can be done by touching the knife jack momentarily on one of the other jacks in use, the table operator listening at the telephone, thus ascertaining whether any conversation is being carried on or not. A better plan, however, is to provide a jack made as shown in Fig. 50, consisting of two metal plates insulated from each other and connected with a telephone badly adjusted, which when inserted between the jack and spring causes no break in the circuit, or leakage to earth, but allows the operator to hear the conversation being carried on without understanding it, owing to the bad adjustment of the telephone, but a whistle or "ring off" is at once heard and understood as a "cut off" signal. This ensures the privacy which is desirable. Each table operator must be provided with a slip of paper and pencil, and each call must be duly entered thus 49—207, that is, 49 called 207. When the subscribers have finished a line can be run through the figures. If from any cause a subscriber cannot be answered at once, or the subscriber inquired for cannot be at once placed in communication, the figures not being crossed out will draw attention to the fact, and the call must be attended to at the earliest possible moment. Calls through a trunk must be kept separate from the others. When the paper is filled it must be handed to the superintendent or the clerk in charge whose duty it is to make up the daily report.

(TO BE CONTINUED.)

A HISTORY OF ELECTRIC TELEGRAPHY TO THE YEAR 1837.

BY J. J. FAHIE, MEMB. SOC. TEL. ENGS. AND ELECS.*

(CONTINUED FROM PAGE 155.)

Chapter III.—Telegraphs Based on Static, or Frictional, Electricity.

Canst thou send lightnings that they may go and say unto thee here we are?
Job xxxviii., 35.

1753.—C.W.'s Telegraph.

The first distinct proposal to employ electricity for the transmission of intelligence, of which we have any record, is that contained in a letter printed in the number of the *Scots' Magazine*, Edinburgh, for February 17, 1753. As this is one of the most interesting documents to be found in the whole history of telegraphy, we will quote it *in extenso* for the benefit of our readers:—

"To the Author of the *Scots' Magazine*.

"Renfrew, Feb. 1, 1753.

"Sir: It is well known to all who are conversant in electrical experiments, that the electric power may be propagated along a small wire, from one place to another, without being sensibly abated by the length of its progress. Let, then, a set of wires, equal in number to the letters of the alphabet, be extended horizontally between two given places, parallel to one another, and each of them about an inch distant from that next to it. At every twenty yards' end, let them be fixed in glass, or jewellers' cement, to some firm body, both to prevent them from touching the earth or any other non-electric, and from breaking by their own gravity. Let the electric gun-barrel be placed at right angles with the extremities of the wires, and about an inch below them. Also let the wires be fixed in a solid piece of glass, at six inches from the end; and let that part of them which reaches from the glass to the machine have sufficient spring and stiffness to recover its situation after having been brought in contact with the barrel. Close by the supporting glass, let a ball be suspended from every wire; and about a sixth or an eighth of an inch below the balls, place the letters of the alphabet, marked on bits of paper, or any other substance that may be light enough to rise to the electrified ball; and at the same time let it be so contrived, that each of them may reassume its proper place when dropt.† All things constructed as above, and the minute previously fixed, I begin the conversation with my distant friend in this manner. Having set the electrical machine a-going as in ordinary experiments, suppose I am to pronounce the word *Sir*; with a piece of glass, or any other *electric per se*, I strike the wire S, so as to bring it in contact with the barrel, then *i*, then *r*, all in the same way; and my correspondent, almost in the same instant, observes these several characters rise in order to the electrified balls at his end of the wires. Thus I spell away as long as I think fit; and my correspondent, for the sake of memory, writes the characters as they rise, and may join and read them afterwards as often as he inclines. Upon a signal

* The author reserves all rights of translation.

† It will be observed that in this and some other systems based upon common, or frictional, electricity, the authors constantly, although often unknowingly, used the earth circuit.

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given, or from choice, I stop the machine; and, taking up the pen in my turn, I write down whatever my friend at the other end strikes out.

"If anybody should think this way tiresome, let him, instead of the balls, suspend a range of bells from the roof, equal in number to the letters of the alphabet; gradually decreasing in size from the bell A to Z; and from the horizontal wires, let there be another set reaching to the several bells; one, viz., from the horizontal wire A to the bell A, another from the horizontal wire B to the bell B, &c. Then let him who begins the discourse bring the wires in contact with the barrel, as before: and the electrical spark, breaking on bells of different size, will inform his correspondent by the sound what wires have been touched. And thus, by some practice, they may come to understand the language of the chimes in whole words, without being put to the trouble of noting down every letter.

"The same thing may be otherwise effected. Let the balls be suspended over the characters as before, but instead of bringing the ends of the horizontal wires in contact with the barrel, let a second set reach from the electrified cake, so as to be in contact with the horizontal ones; and let it be so contrived, at the same time, that any of them may be removed from its corresponding horizontal by the slightest touch, and may bring itself again into contact when left at liberty. This may be done by the help of a small spring and slider, or twenty other methods, which the least ingenuity will discover. In this way the characters will always adhere to the balls, excepting when any one of the secondaries is removed from contact with its horizontal; and then the letter at the other end of the horizontal will immediately drop from its ball. But I mention this only by way of variety.

"Some may, perhaps, think that although the electric fire has not been observed to diminish sensibly in its progress through any length of wire that has been tried hitherto; yet as that has never exceeded some thirty or forty yards, it may be reasonably supposed that in a far greater length it would be remarkably diminished, and probably would be entirely drained off in a few miles by the surrounding air. To prevent the objection, and save longer argument, lay over the wires from one end to the other with a thin coat of jeweller's cement. This may be done for a trifle of additional expense; and as it is an *electric per se*, will effectually secure any part of the fire from mixing with the atmosphere.—I am, &c., "C. M."

From the concluding paragraph it is evident that the writer was not acquainted with Watson's experiments, as detailed in our last chapter, else he would not have suggested insulating the wires, from end to end, with jeweller's cement, and, probably, not even have noticed the objection at all. His suggestions of reading by sound of differently-toned bells, and of keeping his wires charged with electricity, and indicating the signals by discharge, are very ingenious, and deserve to be remembered to his credit in these days of their realisation. The former plan is familiar to us in Bright's Acoustic, or Bell telegraph of 1855, while the latter was, as we shall presently see, employed by Ronalds in 1816, and is realised to perfection in the method now used in signalling through all long cables.

An inquiry as to his identity was first started by "Inquirendo," Glasgow, in *Notes and Queries* for October 15, 1853; then by George Blair, also of Glasgow, in the Glasgow *Reformers' Gazette* for November, 1853, in which he, for the first time, republished "C. M's." letter; and, lastly, by Sir David Brewster, in the *Commonwealth*, for January 21, 1854. Nothing, however, came of the inquiry for a long time, and all hopes of solving the question were abandoned, when, on December 8, 1858, the following letter appeared :—

"To the Editor of the *Commonwealth*

"145, Great Eastern-road.

"Sir: I have not heard that a name has yet been proposed for the 'C. M.' that wrote to the *Scots' Magazine* last century from Renfrew, giving some hints about the electric telegraph.

"I send you what follows, as I think it gives some probability to 'C. M.' being Charles Marshall.

"In our house was a copy of Knox's 'History of the Reformation,' published in Paisley in 1791. My uncle James's name is in the list of subscribers in Renfrew. Anent this my mother spoke as follows :—'There was a very clever man living in Paisley at that time, that had formerly lived in Renfrew. He asked my uncle, as they were acquainted, to canvass for subscribers in Renfrew. The said clever man could light a room with coal reek, and make lightning speak and write upon the wall,' &c.

"That this was the 'C. M.' of the electric telegraph there can, I think, be no doubt.

"Now, it is probable that the man that solicited my uncle to canvass for subscribers subscribed himself; and in Well Meadow, Paisley, I find the name Charles Marshall, and this is the only name in the list of 1,000 names that answers the initials "C. M.' My list, however, is not complete for Glasgow.

"Peradventure some one belonging to Paisley may have somewhat to say of Charles Marshall.

"Alex. Dick."

To this letter were appended the following remarks by Sir David Brewster, to whom the editor appears to have submitted it prior to publication :—"That Charles Marshall might have been the inventor, had we known nothing more than that he was a resident in Renfrew about the time when the letter was sent to the *Scots' Magazine*, was very probable; but when we add to this probability the fact that Charles Marshall was a clever man, and that he was known as a person who could make lightning speak and write upon the wall, and who could also light a room with coal reek (smoke), we can hardly doubt that he was the C. M. who invented the electric telegraph, and that he is entitled to the additional honour of having first invented and used gas from coal."*

Commenting on this correspondence, in *Notes and Queries*, for July 14, 1860, George Blair says :—"That the Charles Marshall who resided at Well Meadows, Paisley, in 1791, was not the C. M. of the *Scots' Magazine*, and therefore not the inventor of the electric telegraph, I succeeded in ascertaining positively about a year ago, on the highest possible authority. Through the kindness of a venerable friend in Paisley, I traced out the fact that a Charles Marshall, who once resided in the Well Meadows, had come from Aberdeen; and that a son of his, a clergyman, was still living. Discovering the address of this gentleman, I applied to him for information; and he states in his reply that he had no doubt his father was the Charles Marshall who appears in Mr. Dick's list; but that he could not be the C. M. of the *Scots' Magazine*.

* * * * * *

"At the time when C. M.'s letter was first disinterred, the most diligent search was made by the schoolmaster of Renfrew, who is also session clerk, not only in the records of the kirk session, but also among the old people of the parish, without a shadow of success; and, strange as it may appear, the name of C. M. remains at the present moment as great a mystery as that of Junius."

(TO BE CONTINUED.)

ARTIFICIAL LIGHTING.

Captain Douglas Galton delivered on the evening of the 19th inst., at the Parkes Museum of Hygiene, Margaret-street, Regent-street, a lecture on "Recent Improvements in Artificial Lighting and their Bearing on the Purity of Air in Rooms."

Sir JOSEPH FAYRER presided, and having formally introduced the lecturer,

Captain GALTON in the course of his address, said: The vast improvements which have taken place in the direction of artificial lighting in recent years—improvements which bear to a considerable extent on the hygienic aspect of the question—make it especially desirable to bring the subject before the public. The introduction of the electric light has had the result of stimulating invention in gas lighting, and there have been recently introduced new methods of gas lighting which bid fair to retard the universal adoption of the electric light for domestic uses. Having traced the great improvements made in the past 50 years in artificial lighting, especially referring to the important improvements introduced into gas lighting by new burners, the lecturer continued: The luminosity of the electric light is due to incandescence. In the case of the ordinary electric light the carbon points brought into opposition become intensely incandescent at the points of contact, and those points can then be withdrawn for some distance from each other without interrupting the current or the light it produces. The flickery arc of flame is far less bright than the carbon points themselves. The particles of carbon of which it is composed detach themselves from the positive pole, which is the hotter of the two, and fly across to the negative pole. As the result of this, after a short time the positive pole becomes shortened, and even excavated, while the negative preserves its pointed form. At the same time combustion of both poles, to a certain extent, takes place, owing to the action of the atmospheric air, and the positive pole which is exposed to the destructive action of the two agents is more rapidly consumed than the negative. The electric arc with its dazzling brightness is subject to fluctuations, from the fact that the carbon points are continually wearing away, and the constant necessity for shifting them renders the arc light often unsteady. Moreover, it is not pleasing in colour, and it has been alleged against it that it produces a quantity of nitric acid, and is thus inimical to the purity of the air in a confined space. Another form of the electric light has, therefore, now superseded the arc light for rooms, namely, the incandescent light, as made by Swan, Edison, and others. In this form of light the electric current is employed to heat a thread of carbon, so as to make it incandescent, and thus to use it as a source of light. For this purpose the carbon is enclosed in a glass globe, from which the air is extracted in order that there may be no oxygen to unite with the carbon during the incandescence, and to destroy

* These letters, copied from the *Commonwealth*, are reprinted in the *Engineer*, for Dec. 24, 1858, p. 484.

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it. This form of light for rooms possesses none of the disadvantages of the arc light, and is, indeed, the most perfect form of light which can be imagined. The light so obtained may be placed any way in a room. It is cut off from all contact with the air of the room, and thus there is no possibility of the purity of the air being injuriously affected by it. The light is thus entirely independent of the ventilation. As hygienists we should always prefer this form of light to any other, and it is probable that eventually the electric light will supersede all others. But I venture to predict that the advances which have been made in illumination by means of gas will probably enable the material to hold its own for some time longer.

Mr. W. DEFRIEZ referred to the sun lamp, a practical illustration of the effects of which had been shown by the lecturer, and said that wherever air was taken from a room, even if not returned in a foul condition, the persons in the room were losers to the extent of the air which had been consumed. He admitted that there was a great deal of beauty in theory in the burners which had been alluded to, but as to all of them there was the question of heat. He thought that Captain Galton had been rather hard in his remarks as to the arc light, because there were arc lights that were more or less steady—lights, moreover, which could not be better for the illumination of large buildings. Nor were they so blue or so white in colour as to be obtrusive. He was inclined to think that we should find (and he hoped in the immediate future) a solution of the difficulties as to lighting with the electric light in one form or another, both as regarded domestic purposes and lighting on a larger scale. He maintained it certainly had the advantage of gas in point of price.

Dr. POORE spoke of the necessity which people would be under in using the electric light in their houses of fitting up an engine and doing other work, and of the advantage of gas in that it could be lighted or extinguished at will. He maintained that defective ventilation was really answerable for many of the objections that were urged against gas, and observed that he would like to see a house built where the architect had thought of gas from the beginning, so that in conjunction with its use there might be a proper system of ventilation.

The CHAIRMAN proposed a vote of thanks to the lecturer, and said he had listened with a great deal of pleasure to Capt. Galton's lecture, and also to the remarks which had been made about it. He had been struck whilst sitting there with the enormous progress of lighting in the past fifty years. He was greatly interested in the new forms of gas burners which had been exhibited—those which did not damage the air of rooms and those which admitted of ventilation, but he neverthelesse felt sure that they were doomed, and that the light of the future was the electric light. It was only within quite a few years that we had seen the electric light in our streets. He did not hope to see a house built where gas had been thought of from the commencement, but where the electric light had been thought of. When one thought of the abominable condition of the air in buildings where gas was used one could not do other than hope for a better form of lighting. He thought that hypercritical remarks were sometimes made in finding fault with the electric light, while it seemed to be forgotten what was in its favour. Just as it was so much more perfect now than when it was when first brought before them, so he felt it would be improved upon in the future, and he was convinced that the time was not far distant when they would see our streets, public buildings, and houses lighted with the electric light. There must, however, be always a great employment of gas, and in the end there would be no great sacrifice to be borne in connection with it.

Captain GALTON in returning thanks for the vote observed with regard to the electric light that he quite believed we were within measurable distance of seeing it applied very generally. When, however, they remembered the enormous amount of capital which had been expended in connection with gas lighting, when they reflected also on the enormous amount of capital which would be required for the adoption of the electric light by the country in the same way as with gas lighting, it appeared to him quite certain that several years must elapse before it was in universal use. Therefore he thought that where it was applied persons would do well to resort wherever they could to some of the new form of light which he had placed before them—lights which would give the public an increased amount of illumnination, with a better and purer atmosphere in rooms.

THE BIRMINGHAM AND WARWICKSHIRE BRUSH ELECTRIC LIGHT & POWER COMPANY (LIMITED).

The second ordinary general meeting of this Company was held at St. Michael's Hall, George-yard, Lombard-street, on the 20th inst., under the presidency of Mr. George Matthew Felton. The secretary (Mr. Harry W. Atkins) read the notice convening the meeting and the minutes of the last meeting, which were confirmed by the present meeting and signed by the chairman as correct.

The report of the directors stated that "the trade profit on completed work although small was satisfactory in proportion to the capital laid out. Your directors have carefully abstained from launching out into unremunerative experimental work. Their policy has been to curtail expenses wherever practicable, consistent with efficiency of administration, and to keep their capital intact available for any profitable contracts which may be offered, and which they feel confident will be offered them during the coming autumn and winter. . . . Your directors consider the general business prospects of the Company are good. They have unremittingly pushed the means at their command, and although it is to them a matter of extreme regret that the result of the first year's operations of the Company has not been sufficient to cover the general expenses, they are by no means discouraged—gas companies and railways paid no dividends in their early days—but feel confident that the general use of electricity for illuminating and other purposes is only a question of time and careful handling."

The CHAIRMAN said: Gentlemen, it is my duty to lay before you the report of the directors, and I, in common with the remainder of the shareholders, am disappointed at the results we show. We are the first of the subsidiary companies who have had the courage to meet their shareholders. We have endeavoured to place before you the state of our affairs as often as we possibly could, and we ask you to look these difficulties with us straight in the face. When we began this Company some fourteen or fifteen months since, you are all aware electric shares were at a very different price to what they are to-day. We, in common with others, have suffered considerably, more especially from the subsequent action of the Legislature and the Board of Trade, by which they have imposed certain conditions upon us, and taken away from us many rights we thought we had purchased and were entitled to. The effect of the action of the Legislature upon us and other companies, of course, has had a deleterious result. At the last extraordinary meeting there was some difficulty with regard to the Lane-Fox patent that is held, or supposed to be held, by the Brush Company. I told you at that time that negotiations were in progress with that company to endeavour to get them to return us a part of the money we had paid for the patent. You gave us the power to do so, and I am pleased to say that we were successful. We had returned to us £17,000 in shares, and £4,000 in cash, making £21,000 altogether. The Company, during the year, have successfully carried out at Saltley, one of the largest carriage manufactories in the kingdom, an installation which has given great satisfaction, and which, I believe, will be the means of opening up a large business in the vicinity. We have letters here in which the Saltley Company express their great satisfaction at the light as installed by us. We have also opened a small installation at Hinckley, and we have letters saying they are also pleased. We are now carrying out an incandescent installation at Kemp's, in Birmingham, who are taking about 350 lights. This is simply an experiment, and from information we have received, and from our own personal knowledge, we have come to the conclusion that there are many works, especially jewellers' works, in the vicinity where the incandescent light would be vastly superior to gas both as regards the health of the workmen and also the light necessary for the business. All these matters we have carried out, with the exception of Kemp's installation. We have negotiations with some half dozen others, but your directors felt they would rather meet you before they concluded these negotiations. It would hardly perhaps be wise to mention the others, inasmuch as with some of them it is merely a question of a few hundred pounds with regard to the terms on which we should light them. Therefore if I mentioned names it would hardly be wise in the interests of the Company [hear, hear]. But I may tell you that at present we are in treaty with about three or four firms, or shops, or institutions, for the light. I may also tell you that we have undertaken no work except at a profit. We have not endeavoured to light any very large town, nor have we applied for provisional orders, because under these our capital would not be sufficient for the amount that has to be deposited according to the recent Act of Parliament. Anybody who is cognisant of town lighting knows perfectly well that it pays neither gas companies nor any one else. We have therefore left that alone, and have endeavoured to light factories and small districts. Now, it is for you to determine to-day whether we shall go on with this Company or not. I have endeavoured at each meeting to put the whole matter before you as fairly as I could, and it is for you to determine what is to be done in future. The directors have been so careful of the cash with which they have been entrusted that we have actually borrowed plant. We have considered it our duty to hire plant rather than purchase it, knowing perfectly well that electric plant under the hammer would be almost worthless [hear, hear]. We have therefore borrowed a little plant for this installation at Kemp's, and we thought it was our duty to take that course until we met you here. As I said before, I believe we are the first subsidiary company that has called a meeting of its shareholders. In proportion to our subscribed capital we are, I believe, perhaps in a better condition than any other of the subsidiary companies; but that is a poor consolation after all if you think the Company cannot be carried on successfully. For my own part I may tell you frankly and candidly that your directors have only one object in view, and that is the interest of the shareholders. There is business to be done if you care to risk it and do it; but if, on the other hand, you do not care, why then I and my brother directors will fall in with your views. I may again say that there is plenty of work to do if you care to take the risks of doing it. I have now to move the adoption of the report and accounts.

Mr. DANIEL R. RATCLIFF in seconding the motion expressed a wish that the report had been better. As far as he could judge, however, no effort had been lacking on the part of the directors. They had, in fact, made great exertions to do business, and he was sure that their manager had done thoroughly well. They lost no opportunity to obtain business, and he could not help feeling that there was a tendency in the country for electricity to be adopted.

Mr. HEROLD thought it would be judicious for the directors to give some explanation of the item of £45,000 for goodwill and concession.

The CHAIRMAN, in reply, referred to and quoted from the agreements mentioned in the prospectus. The patents had cost them £66,000, and as £21,000 had been, as he had previously stated, returned — they having re-sold the Lane-Fox patent—the amount remaining was £45,000.

Mr. HEROLD: And you consider that an asset?

THE CHAIRMAN: It is for you to consider it an asset, not me.

A SHAREHOLDER inquired if it was intended to fill up the vacancies at the Board.

The CHAIRMAN stated that it had been intended to bring this matter forward presently, but he would do so at once as the question had been raised. Mr. Robert Hammond was one of the largest, if not the largest shareholder in the Company, and he had telegraphed to them that day that he was willing to join the Board; and he would be a tower of strength. He need not tell them that the directors, with all their zeal, had not the knowledge which Mr. Hammond had, and having such a large stake there could be no doubt that he would be a great acquisition. If the shareholders thought so Mr. Hammond's election might be proposed by them.

A SHAREHOLDER inquired if Mr. Hammond's shares were acquired by cash.

The CHAIRMAN replied in the affirmative, and afterwards put the motion for the adoption of the report, which he declared carried unanimously. Continuing, he moved the election as a director of Mr. Hammond.

Mr. INCE, in seconding the motion, observed that he did not know that they could make any appointment more likely to assist the Company in doing its business satisfactorily and well.

The CHAIRMAN put the motion, and declared it carried unanimously. He then stated that with the limited business which was being done by the Company he thought it would be better not to fill up the other vacancy at

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the Board. If no other director were proposed he should assume that they did not wish to fill it up.

A SHAREHOLDER inquired the present remuneration of the Board.

The CHAIRMAN: According to the Articles of Association, the directors' fees were to be £1,000, but up to the present they have been £700.

The auditors having been reappointed,

Mr. INCE moved a vote of thanks to the chairman.

Mr. BARKER, in seconding the motion, said he was aware of the very great difficulties which had attended the electric light—the same difficulties which had attended the launching of gas and other new inventions in this country. He believed, however, if the directors continued their present cautious action that the time would come when the shareholders would reap the benefit of the patience they had shown up to the present time.

The CHAIRMAN, in reply, stated that he held a large interest in the Company, and he need not say that they were all to some extent in the same boat. He very much regretted that he had not put his money in New River shares instead of electric light shares, but some day probably electric light shares would be as good as New River shares.

The meeting then separated.

THE UNITED TELEPHONE COMPANY.

The third annual ordinary general meeting of this Company was held at the City Terminus Hotel on the 24th inst., Mr. James Brand in the chair.

The MANAGING-DIRECTOR (Mr. Joseph B. Morgan) read the notice convening the meeting, and the minutes of the last meeting were taken as read.

The CHAIRMAN then said: I have now, gentlemen, to move that the report and accounts be received and adopted. You will, of course, naturally expect me to say a few words on the subject. When I took leave of you last year I hoped that we might have peaceful times before us that we might make use of to develop our business, and begin to acquire the fruits of our labours. The entire opposite has been the case, and I may say that during the whole of the past year we have not had one month free from worry, anxiety, and trouble. We have not only had constant fights with infringers who seek to reap the harvest we have sown, but we have had to fight one of the most determined battles in the Court of Appeal in defence of our property which has been fought out in this country. This fight and the previous ones we have kept you fully informed of from time to time, but there is one you have not heard of, which I think I ought to say a few words about, as had we not won it, or virtually won it, it might have been a serious matter. You will remember that in May last year Mr. Justice Fry decided an action brought by us against Messrs. Harrison, Cox-Walker, and Co., in our favour on all points except on a technical objection to the effect that, as we had included in our invention the phonograph, which was not in our first specification, our patent was void until we had disclaimed the phonograph, and this the Attorney-General gave us leave to do. We took the necessary steps in this matter, and the disclaimer was granted in August, 1882, nearly three months after our application. And in this delay was the great danger to which we were subjected by Mr. Justice Fry's decision; for, during the interval between the decision and the granting of our disclaimer, all telephones under the Edison patent that were manufactured, or were *bonâ fide* contracted to be manufactured, might have been protected by the *fiat* of the Attorney-General. Our opponents therefore came before the Attorney-General and claimed protection for 800 Blake transmitters and something like 8,000 of the instruments called Hunning transmitters. The result of this attempt to obtain protection before the Attorney-General was that of the telephones alleged to have been *bonâ fide* contracted for during what may be called the interregnum of the Edison patent rights, only the 800 transmitters were protected, and the Company, being the owners of the Blake patents, have been able to prevent the use of these instruments. The remainder of the instruments claimed to be protected were held by the Attorney-General not to have been *bonâ fide* contracted for, and this can hardly be an agreeable reflection for those who put forward this very outrageous claim. I think we may congratulate ourselves on this termination of a matter which might have turned out inconvenient for the United Telephone Company. With these explanations I think I have said enough as to our legal position. It has been said that we spend a great deal of money in law. This is, unfortunately, true, but it is impossible to help it. It is also said that we go to law to create and maintain a monopoly. This is not true. We should be glad, of course, to have a monopoly if we could get it, but the Postmaster-General has effectually provided against such a contingency. If, however, we cannot get a monopoly of telephone business, at any rate we have a right to the monopoly of our own telephone instruments that we have bought and paid for, and that is why we go to law—for the same purpose as a householder bars his doors at night to prevent his house from being broken into by burglars. I now come to the report. I do not think I need say much as to the first two items in the report. The figures speak for themselves, and the large increase in the revenue in return for the sum expended on capital must be satisfactory to you. I think we must take credit to ourselves and the managing director that this large increase of revenue has been earned with a moderate increase of working expenses. As to depreciation, we feel confident that we have made ample allowances on that score, and we continue to reckon the large interest we hold in our subsidiary companies—our shares in which, although very valuable, are not taken into our accounts as far as profit and loss are concerned—as more than ample provision for such a decrease, if any, as may occur in the book value of our patents. As a matter of fact, these shares are growing into value every day, as the income of the companies they represent, like our own, is daily increasing. The Lancashire Company and the National Company have now each a gross income exceeding £50,000 a year. They are most valuable auxiliaries in the development of telephone enterprise in England and Scotland. The Irish and Northern Company's business is also steadily increasing. Our dividend is not yet a very large one, but, as I said last year, when we declared a modest 5 per cent., it is honestly earned. We might have paid you something more no doubt, but we thought it safer, and that you would be better satisfied, if we erred on the side of caution, providing amply for every possible depreciation, and carrying forward a balance towards any contingency that might arise next year. As to the issue of capital, we shall want some more money as our business increases, and we want to repay to revenue what we have spent on capital account. The £2 premium with the balance carried forward will more than repay this, and the further increase in the market value of the shares we think it fair to place at the disposal of the shareholders. As to the progress of the business, the figures to the 30th April are before you, and since then we have opened the Millwall Exchange, and an exchange at the Edgware-road, and there are one or two I think on the point of being opened, but we have not yet quite arranged with the Post Office authorities. There are fresh subscribers coming every day, and yesterday, I am glad to tell you, after surmounting very great difficulties, both electrical and otherwise, I had the pleasure to speak through, for the first time, to the House of Commons. I hope in a very few days that the full advantage of our system will be placed at the disposal of both Houses of Parliament, and also at the disposal of the public who are engaged in parliamentary business in the committee rooms. I think this cannot fail to act as a very excellent advertisement for us. We think we have made great progress, but some of you may think we might have done more. I do not know whether we could. It has not been for want of trying. You must remember we are making good our ground as we go along, and we are not trying to make a show by flashy erections here and there of single wires at great distances. We are making our centres good, and slowly and surely pushing out to the suburbs, and on that point we hope to say more to you next year. I hope you will bear in mind that we cannot and must not compare the circumstances which surround us here with the circumstances that exist in America, where the use of the telephone has become a necessity of daily life. Here we still find it difficult to convince some people that they cannot and ought not to live without the telephone, and the development of our business is daily accompanied by worry, anxiety, and constant irritation. One of the greatest sources of irritation, as far as I am concerned, is the fact that I know many of our shareholders, having a large stake in our prosperity, will not even help their own interests forward by becoming subscribers. I think I am surely entitled to ask for their aid in this matter. Every fresh subscriber is a fresh inducement to others to join our system. As to the Post Office, I may say that our relations are very friendly indeed, and I hope they are beginning to look on us not as opponents to their telegraph business, but as valuable assistants and contributors to the revenue of their department through our rapidly increasing royalties. I think I have touched on all the subjects in the report. As to the future I can only say that I believe that telephony is in its infancy, as far as this country is concerned. I am sure that before long you will have your houses connected with your places of business. I have had mine so connected for a long time past, and it has given me many an hour's ride in the morning before I came to look after your business. You have no doubt seen by the circular we issued some little time ago that a conversation had been held between Chicago and New York, a distance of something like 1,000 miles, and you will be glad to know that this wonderful feat was accomplished by the use of the instruments for which you hold the patent rights—the old original Edison transmitter and Bell receiver, so that when the arrangements for the trunk lines for our long distance telephony are completed, you will find yourselves possessors of instruments not only capable of talking over a few yards or a few miles, but of talking over any number of miles that are requisite, at any rate in this country, as it is now proved beyond doubt that, provided perfect insulation can be obtained, conversation with your instruments can be maintained over unlimited distances. We are only waiting for the completion of some experiments we are making to carry out, with the aid of the Post Office authorities, our lines to Brighton, Birmingham, Manchester, and Liverpool. For all these places we have business offered to us. I have touched fully on all the points that have occurred to me, but I should be glad to answer any questions. I cannot sit down, however, without paying my public thanks and expressing my gratitude and that of every one of my colleagues, for his energy, ability, his untiring zeal, and his immense devotion, to our excellent friend and managing director, Mr. Joseph Morgan.

The DEPUTY-CHAIRMAN (Mr. J. S. Forbes): Gentlemen, after the graphic description which our chairman, according to his wont, has given you of the progress of the business, I shall only say a few words. One or two points he has not adverted to in detail I might for your information call your attention to, that you may have evidence of the growing use of this most wonderful invention. The chairman has described the difficulties under which the concern labours. They are very great. One of the most difficult things in the world is to teach people something for their own benefit, and in this country we are notoriously slow to learn, being very conservative. But here are some facts to show that the effort to teach in our case is not thrown away. We have had the pleasure within the last few days of receiving a very large number of calls in one day—22,255 calls. As to the progress of the totality of our business as represented by the use of the instrument (because after all the development and the value of this property will turn on how far it is or is not recognised as a useful auxiliary to every-day life), in the first year of our operations there were 943,800 calls; in the second year the number was transformed into 2,313,000; and that figure, oddly enough, in the past year has been exactly doubled, the 2,313,000 having got up to 4,698,000. Just turn that over in your minds and consider what it means. The enormous amount of convenience and social comfort to meet in conversation 4,698,000 times on matters affecting ourselves! Of course those converted to our teachings are manifest by the increase in the subscribers' list. That, after all, is the test. There are two tests—how many more people and how much more they use the telephone when they can. The numbers are always progressing. To-day we have on the exchange lists 2,899 subscribers. I remember the time when 2,000 was considered a large number, but we are getting very nearly 3,000 now. I, for one, having occasion in my own business to appreciate as much as most men the advantages of this instrument, and the utterly insignificant price at which such important results can be secured, have no hesitation in predicting that the extended knowledge of this thing will rapidly lead to its very extended use, and a very extended increase in the number of subscribers. That is as regards the exchange business. There is another source of revenue to the Company which is not immaterial, and that is the private wire business. That is progressing in a very advantageous way. Whereas in 1881 we derived from private wires £2,988, in 1882 we received £4,370, and in 1883 that has increased by more than double—it has got up to

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£9,402, and of course one knows perfectly well that, with people who are growing familiar with this business, there is an almost inexhaustible source of profit to the Company and convenience to the public. That is a thing that is appreciated very largely. I am the happy possessor of a private wire, for which I am content to pay what I think is an extremely small sum, and if it were doubled I could not dispense with the convenience. The chairman has indicated to you the great difficulties that we have had to contend against. You may read them and see them about you. Not only have we had to deal with infringers, not only those people who are ever ready to avail themselves of the fruits of others' exertions, but difficulties arising from the very nature of a novel business little understood, either by those immediately concerned in it or by outsiders. Overhead wires and way-leaves present innumerable difficulties, and compel those who have the conduct of affairs, and more especially our esteemed managing director, Mr. Morgan, to be very careful, to go slow and sure. Any attempt, as the chairman has said, to force this thing along—to extend it for the mere purpose of flashy effects—might lead to very disastrous results. We are going safely and slowly, and I think we may predict surely. As to the dividend, I am mixed up with some concerns which induce me to look on a 6 per cent. dividend as something beyond the dream almost of hope, but there are some other people who are more sanguine who think that a 6 per cent. dividend is not, after all, very much. It seems, however, a reasonable dividend, and especially as in the accounts, and those who are conversant with accounts will see, as the chairman has said, that very ample provision has been made—as there ought to be in a business of this sort—for depreciation of material and plant, and there is a very handsome balance carried forward. I think on reflection that any one who expected a larger dividend will see the wisdom of the course the Board has taken in keeping their disbursement at the moderate and yet not unhandsome sum of 6 per cent. I think that will hardly want an apology. The speaker then proceeded to endorse the eulogistic remarks of the chairman with regard to Mr. Morgan, and also spoke of the very great tact and temper displayed in very trying times by the chairman, whose devotion to the interests of the Company was extremely great. He had no hesitation in saying that any remuneration received by the chairman in the shape of fees from the Company was utterly inadequate to the value of the services he had rendered.

The CHAIRMAN desired, before they proceeded any further, to recognise the very skilful and devoted services of the Company's staff in every department.

Mr. GALSWORTHY expressed his satisfaction that he had heard no further reference since eighteen months or two years ago to the question of the Government buying up the telephone property. He considered that the longer that was delayed the more the telephone shareholders would benefit. He referred with satisfaction to the decrease in the percentage of the working expenses, and stated that he was not surprised to hear from the chairman that the law expenses had been heavy, seeing the battles that they had had to fight to preserve their property. He was glad to see that the dividend was only 6 per cent., because it was progressive. He thought that the new shares had been issued in a very fair manner. He expressed his satisfaction at the remarks of Mr. Forbes showing the progress which the Company had made. The main difficulty he supposed that they would have to contend against in the future was the overhead wires. It was very necessary for them to keep their instruments in a perfect state, so that communication might be carried on with the greatest possible facility.

Mr. GEORGE HOPKINS observed that the Company were the owners of £410,000 in shares of other companies, and during the half year he saw that they received, or it was estimated that they would receive, £3,500 in the shape of dividend on those shares. That, however, was very small.

Mr. TAPP stated that the gross income had increased by £24,000, while the expenses were increased by £17,000, so that after all they were only £4,800 better off than last year. The expenses had increased over £6,000, including the depreciation, and the royalties, he found, showed a decrease of £500, which would seem to show that the business of the Company was decreasing in the country.

The CHAIRMAN, in reply, stated that with regard to the increase in the expenses, provision for depreciation was included, but that was a point that they thought they must take care of in the interest of the shareholders. The business in the country was increasing as it was in London, but in the previous year's accounts the amount of royalties shown was for a longer period than twelve months, whereas in the present accounts only a year's royalties were included. Of course the shares that they held in the other companies did not give them the return they looked for. The Lancashire and Cheshire Company gave them a considerable return, but that was the only one that they yet derived an income from. In the National Company they came in for dividends only after 6 per cent. had been paid, but he was sure that the National Company was prospering. Besides the large stake they held in the prosperity of the sub companies, as regarded dividend, they also received a royalty for every telephone used. He did not think with Mr. Galsworthy that they would have greater difficulties to meet with in the future than they had in the past with regard to overhead wires. He believed that, as the enormous benefits of the telephone became known, they would obtain greater facilities in putting up way-leaves. They had certainly improved in the working of the system, but intelligence was required on the part of the user, as well as on the part of the operator. He referred to the congested condition of the principal streets in London with telegraph wires, pneumatic tubes, and gas and water pipes as against putting telephone wires underground. They had made over Scotland to the National Company, and the telephone was being worked at Glasgow, Edinburgh, Dundee, Aberdeen, and Greenock, and a great many other places.

The report was then unanimously adopted, the dividend was declared (free of income-tax), and the retiring directors and auditors were subsequently re-elected.

On the motion of the CHAIRMAN, seconded by Mr. FORBES, a resolution was passed confirming an agreement made with Mr. Robinson Kendal for granting to a company intended to be formed, under the name of "The South of England Telephone Company (Limited)," exclusive licenses for the use of the company's patents in certain districts, partly in consideration of fully-paid shares in such company, and partly in consideration of royalties; and, in connection with such licenses, to sell for fully-paid shares and cash any business now carried on by the company within the districts comprised in such licenses respectively, and any property used in such business. Replying to Mr. Hopkins, the chairman stated that the general basis of the agreement was set forth in the report. The capital of the proposed company was to be £50,000 in preference shares, and £200,000 in ordinary shares. One half of the ordinary shares would belong to this Company, and on those shares dividends would be paid after 6 per cent. had been paid on the £50,000.

On the motion of Mr. AGNEW, M.P., a cordial vote of thanks was passed to the chairman, who acknowledged it, and the proceedings terminated.

INDIA RUBBER, GUTTA PERCHA, AND TELEGRAPH WORKS COMPANY (LIMITED).

A half-yearly general meeting of this Company was held at the Cannon-street Hotel, on the 24th inst., "for the purpose of obtaining the sanction of the shareholders to the payment of an interim dividend." Mr. George Henderson presided.

The SECRETARY (Mr. W. J. Tyler) having read the notice convening the meeting,

The CHAIRMAN said: Gentlemen, our half-yearly meeting is usually an informal one, being convened merely for the purpose of recommending the payment of an interim dividend, but before moving a resolution to this effect, I would briefly recapitulate the events of the past half year. I am glad to say that we have been fairly employed, and I have no doubt that when our accounts are made up it will be found that we have earned a considerable profit on our outlay. Our general sales have kept pace with last year's figures, and we have had some occupation, but not as much as we could wish, for our cable machinery and vessels. The "International" has had repairing work to do, as has also the "Dacia." The latter was chartered by the Government to repair some of their cables and to lay a heavy cable for Her Majesty's Post Office Department, which we manufactured for them in the early part of the year. We have other work in hand at Silvertown for this department, while at Persan we are busy for the French Government. Our cable works and steamers will be partially employed during the second half of the year in manufacturing and laying about 1,900 miles of cable to connect Spain with the Canary Islands, and these again with Senegal under concessions and money subventions from the French and Spanish Governments. These cables are to be completed and laid by the end of the year, and soon thereafter we hope to meet you again with a good account of the year's business. Meanwhile, I have merely to move, "That an interim dividend of 5 per cent., or 10s. per share, free of income-tax, payable on and after the 25th inst., be now declared."

Mr. S. W. SILVER: I have much pleasure in seconding the chairman's motion (which was carried unanimously).

Major RAMSAY L'AMY: I think we cannot do other than offer a vote of thanks to the chairman and directors for the satisfactory statement of our affairs which has been placed before us.

Mr. HANSON briefly expressed his pleasure at seconding the motion, which was carried unanimously.

The CHAIRMAN: I beg to return you our best thanks, and hope we shall have a good account to give you at the end of the year.

The proceedings then terminated.

TELEGRAPH CONSTRUCTION AND MAINTENANCE COMPANY (LIMITED).

The half-yearly general meeting of this Company was held on the 24th inst., at the office, 38, Old Broad-street, Sir Daniel Gooch, Bart., M.P., in the chair.

The CHAIRMAN said: As these meetings are held more for the purpose of enabling you to ask questions than anything we have to tell you, as you know there are no report or accounts, we shall be very glad to answer any questions that are put, but, in the meantime, I may tell you what work we have been doing during the past half year. The total quantity of cable manufactured during the past half year has been 2,617 nautical miles. A cable 95 miles in length has been laid in the China Sea, between Hong Kong and Shanghai, for the Eastern Extension Company. A cable 1,402 miles in length has been laid in the Red Sea between Suez and Aden for the Eastern Telegraph Company. The "Scotia" and "Seine" are now engaged in laying two cables for the Great Northern Telegraph Company, viz., one between Shanghai, in China, and Nazaski and the Russian port on the coast of Koria. The length of this cable is about 1,356 miles. All have been laid successfully, and the works we still have in hand we hope to keep us going a little longer. Then, as you are aware, we took parliamentary powers the other day to enable us to commence electric lighting. Those powers received the Royal Assent, and we are now before committee for the purpose of endeavouring to secure some portion of the lighting of a part of London in St. James's and that district. The matter is now before committee, but what the result will be I do not know. We are seeking to obtain a beginning there. We have not, of course, lighted any place yet; but every effort will be made to secure work of the kind. We have lighted our own works at Greenwich of course for the last twelvemonths, and it is very successful there. The machine we use is not only an economical one, but it seems a very effective one. If there is any question any shareholder would like to ask, I shall be very glad to answer it. I am afraid I have no other information to give.

Mr. W. ABBOTT: As a shareholder mainly responsible for the introduction of the system of half-yearly meetings, I think I may fairly congratulate my fellow proprietors on the desirability of meeting you every half year, particularly when you have such a story to tell as that which you have just unfolded. The reticence with which the work of the Telegraph Construction and Maintenance Company is always carried on, and the unostentatious way in which they go about their contracts is such that we should be in ignorance that you had laid such a large number of miles

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for various companies, and so extended the submarine cable system of the world, if we had not had the pleasure of meeting you to-day [hear, hear]. But on that other point you have touched upon, and which, I presume, accounts for a larger attendance here to-day than usual, that is the question of electric lighting, valuable as our submarine business is, I am perfectly certain, with the great prestige this Company enjoys, this additional adjunct to the business will be equally valuable with the submarine cable business [hear, hear]. It seems to me a lamentable thing that the Board of Works and the vestries appear to be contending with each other in obstructing the development of the electric light in London. Of course, you cannot expect much from the mind of a vestryman, but we do expect something from a powerful organisation such as the Board of Trade [cheers], but all seem to be afraid of giving permission to any great company. What is the result? Trade is paralysed. The copper market, which has been waiting to be galvanised into life by increased demand, is paralysed, and I hope, sir, you will use your influence in Parliament to wake these gentlemen up a little, because we want something of that kind to distribute money, and to do good to trade [hear, hear]. I think I express the views of my fellow proprietors when I say that what you have told us just now has given us intense satisfaction [cheers].

There being no business resolution to propose, on the motion of Mr. Abbott a vote of thanks to the chairman and directors terminated the proceedings.

THE DIRECT UNITED STATES CABLE COMPANY (LIMITED).

The twelfth ordinary general meeting of this Company was held at the Cannon-street Hotel, Cannon-street, on Thursday, the 26th inst. John Pender, Esq., M.P., presided.

The Secretary and Traffic Manager (Mr. J. W. Fuller) having read the notice convening the meeting,

The Chairman said: Gentlemen, you have had the report in your hands for some days, and I presume you will take it as read. Before asking you to approve of it, I will, as usual, refer to some of the figures in the report, so that you may fairly understand and appreciate them. The revenue for the half year to 30th June last, after deducting out payments, amounted to £70,529 19s. 5d., and the working and other expenses, including interest on debentures and income-tax, absorbed £19,315 8s. 9d., leaving a balance of £51,214 10s. 8d. as the net profit of the half year, making with £1,286 16s. brought from the previous half year a total of £52,501 6s. 8d., which has been appropriated as follows:—Interim dividend of 5s. per share to 31st March, £15,177 10s.; proposed final dividend of 5s. per share to 30th June, £15,177 10s.; depreciation of spare cable tank, £416 1s. 6d.; transferred to reserve fund, £19,877 17s. 3d.; balance carried forward, £1,852 7s. 11d.; making a total of £52,501 6s. 8d. The Company's revenue is larger by about £9,500 than in the corresponding period of 1882, but owing to the different tariffs in force in the two half years, and to the operation of the joint traffic agreement of May, 1882, these figures afford no reliable comparison; but, taking the Atlantic traffic as a whole, and comparing it with that in the same period of 1881 (two years ago) when similar tariffs were in force, we find, as stated in the report, not only no increase, but a slight reduction in the earnings during the past six months. The expenses in London, as shown in abstract A of the accounts, remain practically the same as in 1882. On the whole they are about £80 less than in June last year. The expenses at stations show a large reduction of about £2,550 owing to our new arrangements on the American side. Although this reduction may not be maintained, every effort will be made with a view to its continuance. The remaining items of expenditure, mostly fixed charges, call for no special remark. The reserve fund has been increased by transfer from revenue and by interest on the investments to the sum of £315,000, and the present market value of the Company's investments is considerably in excess of the amount of their cost to the Company. Gentlemen, that is a very satisfactory state of affairs, looking at the times which we have passed through, and more particularly to the present time, when there is such a great amount of depression in trade, not only in this country but in America. I was told the other day by a very old and experienced operator on the Stock Exchange that he never remembered but once in the period of a long life such a state of stagnation as existed at the present time. Now, I have found in my experience of telegraphy that it is about the best barometer of trade that exists. When trade is active telegrams are freely indulged in. It is a grand luxury in commerce. It is the beginning of every operation. Many telegrams are transmitted before an operation is completed, and when it is completed it is wound up by a telegram. The present depreciation is one reason for the state of stagnation in our receipts, but on the whole I think we have reason to congratulate ourselves on the position we occupy to-day. When I last addressed you, six months ago, my remarks were most full and complete—so complete that it was pretty much the history of telegraphy for years past, and it covered the ground to-day. I therefore do not intend to inflict on you such a speech as I made when I last addressed you, but I will say this—we had then just opened an independent office in New York, and I am glad to say that that has been attended with very signal and marked success. Human nature, gentlemen, is the same all over the world. People like two strings to their bow, and that they find in America by the opening of this, what I may call independent submarine telegraph office. There is a considerable amount of excitement now in America on account of the strike of the telegraph operators, and I am glad to find that our office has proved of enormous value in keeping up without any interruption whatever the communications between America and this country. The other companies have done their part—they have done it well, but, at the same time, we are entirely and completely independent of the Western Union system, and therefore we are not subject in the slightest degree to be controlled by the Western Union, and the Western Union operators are those who are on strike. I have always felt strongly in favour of an independent office. I have always felt strongly that a monopoly in anything is not a pleasant or acceptable system to Englishmen. We had only the other day perhaps one of the most marked expressions of public opinion against monopoly that has occurred in modern times. I have heard it said that our telegraph system is a great monopoly. I deny it. It is no monopoly. We have between England and America at the present time four distinct companies carrying on telegraphic communication between the old and the new worlds. There are three distinct companies carrying on telegraphic communication with India and the far East. That gives people an opportunity, if they are displeased with one system, to take up the other systems, but I hold, at the same time, that while you meet public requirements and public demands by having these respective offices, you are at the same time bound to see that the public get a thoroughly efficient and good service, and looking to the continuity which is requisite in conducting telegraphic enterprise, it is an absolute necessity that the companies who are operating should have a perfect understanding with one another, so as to carry out the system in a thoroughly efficient manner, and thereby benefit the public, and not destroy the interests which the shareholders are fairly entitled to. These are my opinions, gentlemen, as to the way in which important enterprises like this should be conducted. I believe we have conducted this enterprise upon a very sound policy, and I think when one looks back to the very few years in which this Company has been in existence, and looks at the reserve fund which has been accumulated, and at the steady 5 per cent. which has been paid, he will see that we have no reason to regret the change which was made. We believe that while we have benefited the shareholders, we have very largely benefited the telegraphing public. As to the future of telegraphy I believe it is comparatively in its infancy. I believe it will always be the pioneer of trade. I believe that trade will be largely increased and benefited by telegraphic communication. I think we may congratulate ourselves as holding a sound property, and one which, if conducted with wisdom and judgment, will always command respect and attention from the great body of the public. With these remarks, I beg to move the following resolution:—"That the report of the directors, dated 13th July, 1883, together with the statement of accounts to the 30th June, 1883, annexed thereto be and the same are hereby adopted, and that a final dividend be now declared of 5s. per share, free of income-tax, making, with the interim dividends already paid, a total dividend of 5 per cent. for the year ending 30th June, 1883."

Mr. William Ford: I beg to second the resolution.

The Chairman: Before I submit this motion is there any gentleman who wishes to make any remark. I like, as I have said on previous occasions, to have opinions from the body of the hall, and I am always prepared to give any gentleman the best answer in my power.

Mr. John Newton: There is one subject on which I feel a little strongly—the threatened opposition from the Lord Mayor that is to be, of a new telegraph cable. We have seen advertisements lately of that competition—announcements, not advertisements in the usual sense, though they are advertisements. I think the shareholders of the existing telegraph companies should express their desire that in dealing with any new competitor you should not attack the threatened new company, but its directors—that you should make no terms whatever with another competitor that will involve the creation of a number of seats on the directorate. That is the evil of competing companies, and if you will fight in that sense—that there shall be no possible chance of these men getting seats on the Board—I think you will put an end to all attempts to establish competing companies. We have enough companies now surely, and I think, if you deal with them in the manner I have suggested, you will be able to buy such ventures up—if not at 5s., at least at 10s. in the pound. Do not let that 10s. include the continuation of the services of the gentlemen who have caused the interference with our property, and so prevent them from turning over the comfortable directors' fees afterwards.

The Chairman: Mr. Newton has drawn our attention to a new company. The fact is I attach so little importance to the movement that I did not think it was worth consideration or worth noticing at a meeting like this. As, however, Mr. Newton has referred to it, I think I may simply say that interests—large and important interests—have paused before going into such a transaction where cables were not required. I refer to Mr. Garratt and those who are really men of power and influence, and I believe the next cable that comes would be from that quarter, not from the source to which Mr. Newton referred. I believe there is no backbone in the one, but a great deal of backbone in the other. There are, however, at the head of one, men whose interests are great and very important: but I do not wish to go into that question just now. We are at peace. We have had twelve months' peace, and I hope we shall have another similar period of peace. The Atlantic, however, is a great sea, and presents a very fine opportunity for those who fancy that they can make money out of it by what I call promoting companies, but I am quite certain of this, that we have a very important advantage in the fact of having eight cables working at the present moment, and as the essence of telegraphy is time, there is no company with one or two cables that could compete with us. Those who have to pay £1 or £2 for a telegram will always take advantage of the best system, and we are in such a position as justifies us in claiming that advantage. [He then put the motion in the usual manner, and declared it carried unanimously.] Continuing, he said: Gentlemen, the next motion is one that is personal to myself, and it will be moved by Mr. Underdown.

Mr. E. M. Underdown: It is a very pleasant duty to me to have to propose the re-election of our chairman at this Board. You will remember that six years have passed since we first began the work, which has been very properly stated by the chairman to have been admirably and successfully carried out. It is useless that I should repeat what he has said. Without saying anything about the Company as it was before we now know that we have paid a satisfactory dividend for some years, and have accumulated a satisfactory reserve fund. Now, the policy which led to that happy result was the policy of our chairman. It is due to him the success which has attended this policy, although you may well know it, you cannot know as well as we do on the Board the indomitable perseverance and the extraordinary energy with which he has thrown himself into all matters that bear on the prosperity of this Company—not only the prosperity of this Company, but the prosperity of that in which he takes so lively and so thorough an interest—the prosperity of telegraphy in general. The chairman has used the words "history of telegraphy;" and when the history of telegraphy comes to be written I believe that the name of our chairman will be that which will occupy

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one of the largest chapters in it. I know that he himself will feel the proudest that, among all his other achievements, his name should be associated with that very gigantic and important series of enterprises. It only remains for me to say that the respect which I am sure you all have for him by the friendly way in which you receive him at these meetings is sincerely felt by his colleagues at the Board, with whom he has always maintained the most admirable relations, and we all hope at the Board that he may sit among us for many years to come, and occupy the position he has filled so long and so well. I now beg to move :—"That John Pender, Esq., M.P., be and he is hereby re-elected director and chairman of this Company."

Mr. C. J. GUNTHER : I have great pleasure in seconding the motion.

Mr. UNDERDOWN put it, and it was carried unanimously.

The CHAIRMAN : Gentlemen, there is nothing more pleasant to me than to hear the words which Mr. Underdown has spoken as applied to my connection with the Board. As you know, a chairman cannot do much unless he is in perfect harmony with his Board, and it so happens that in all the proceedings connected with the Direct Cable Board there has been perfect harmony. We have carried out the work with a desire that it should be a success, and I think we may fairly, in what we have put before you, say that we have not been unsuccessful. As I have said, I believe telegraphy has yet a great work to do, and I am very proud, and shall always be proud, at the way my name has always been more or less associated with it. I thank you for having re-elected me a director of this Company, and while I continue a director, we shall take an important part, not only in maintaining the position that telegraphy has attained, but also in placing it in a yet higher position. Governments are only beginning to recognise the importance of telegraphy. There is not a point at the present moment either of political or commercial importance throughout the world that telegraphy has not reached. Only the other day I had the honour of concluding an important negotiation with the French Government to connect a new colony, which they are aspiring to possess, with our system. In fact, it will be impossible now to govern distant colonies unless they have telegraphic communication. Therefore we have a great work to do, and we intend to do it not only in the cause of human progress, but I hope also to the benefit of our shareholders. Now, the next resolution I have to propose is—"That Emmanuel Maguire Underdown, Esq., be and he is hereby re-elected a director of this Company." I think it will be out of place for me to repeat the compliments that Mr. Underdown has paid to myself ; but if I were quite at liberty, I would say that I have found in Mr. Underdown a most excellent, and worthy, and intelligent supporter of the policy which has been pursued, and that it would be difficult to place on the Board a man whose knowledge of international affairs is greater than that of my friend Mr. Underdown. We have had occasion more than once to draw very fully on that great store of knowledge which he possesses in that direction. I think I may remind you that he has been before the public lately, and has given a joint opinion which I think will register his name among the great men of the day, an opinion owing to which I believe this country has been saved from making one of the greatest possible mistakes which it could have made.

Admiral the Hon. Sir HENRY KEPPEL, G.C.B., D.C.L. : I have much pleasure in seconding the motion.

The CHAIRMAN put the resolution, and it was carried unanimously.

Mr. W. BARBER : This resolution, which belongs to ourselves I think, has been put into my hands to move :—"That Messrs. John George Griffiths and John Sawyer be and they are hereby re-elected auditors of this Company's accounts for the ensuing year."

Mr. T. STOKES : I beg to second that resolution (which was carried unanimously).

The CHAIRMAN : I believe, gentlemen, that that concludes the business of the day.

Mr. NEWTON : Mr. Chairman, I beg to move a vote of thanks to you and your colleagues for the manner in which you have carried on the affairs of the Company during the past half year. The shareholders must be satisfied to see the way in which their affairs are conducted. We have got a fairly satisfactory dividend under the circumstance that we have a single cable and a very large reserve fund, and the policy of the directors is one that must commend itself to all permanent and conservative investors in the Company, as it indicates that it will not be very long before we shall see a slight addition to the dividend under the influence of our increasing reserve fund.

Mr. GRIFFITH : I beg to second the motion (which was carried unanimously).

The CHAIRMAN : I beg to thank you, gentlemen, on behalf of my colleagues and myself. We appreciate all the kind words we receive from the body of the shareholders, and I may say that it is our desire to merit kind words. If you are pleased to-day, I hope it will only be an incentive to us to go on doing, if possible, better than we have done heretofore.

The meeting then separated.

ANGLO-AMERICAN TELEGRAPH COMPANY.

Report of the directors to the ordinary general half-yearly meeting of the proprietors, which will be held at the City Terminus Hotel, Cannon-street, on Friday, the 3rd day of August, 1883, at 2 o'clock p.m. The total receipts from the 1st January to the 30th June, 1883, including a balance of £6,949 1s. 6d. brought forward from the last account, amount to £247,458 15s. 9d. The traffic receipts show an increase, as compared with the corresponding period of last year of £36,333, consequent upon the resumption of the 2s. tariff. The total expenses of the half year, including repair of cables, income-tax, &c., as shown by the revenue account, amount to £54,195 1s. 8d. The directors, under the powers conferred upon them by the Articles of Association, have before declaring the net profits set apart the sum of £75,000 to the renewal fund, leaving an available balance of £118,263 14s. 1d. to be dealt with. One quarterly interim dividend of 15s. per cent. on the ordinary stock, and of 30s. per cent. on the preferred stock, free of income-tax, was paid on the 1st of May, 1883, absorbing £52,500, and a second quarterly dividend at the same rates will be paid on the 1st August, 1883, leaving a balance of £13,263 14s. 1d. to be carried forward to the next account. The Company's repairing steamship, "Minia," has been engaged during the half year in repairing the St. Pierre-Duxbury cable, laid in 1869, the South Placentia cable laid in 1873, and upon the inspection and repair of the heavy shore ends of the cables landed at St. Pierre-Miquelon. The Company's entire system of cables is now in good working order and condition. In the month of September next the steamship "Minia" will come to London for the purpose of taking in new boilers, the present ones being worn out. A contract for the supply of the new boilers has been entered into, and they are now in course of construction. An arrangement has been made between the European cable companies and the Western Union Company for the establishment of a cable office at New York, under the exclusive management of the cable companies. This office was open to the public on the 22nd January last, and appears to have given general satisfaction. In September, 1880, a joint purse agreement was entered into between this Company, the Direct United States Cable Company, and the Compagnie du Télégraphe de Paris à New York. Mr. G. P. Harding, of Paris and London, took a very active part in arranging the numerous points of difference between the companies, and in acknowledgment of his services the directors have agreed to pay Mr. Harding a sum of £4,500, which will appear in next half year's accounts.

COMPANIES' SHARE LIST.

TELEGRAPHS.

COMPANIES.	CLOSING PRICES JULY 25.		BUSINESS DONE WEEK ENDING JULY 25. Highest.	Lowest.
Anglo American ... x d.	48,	48½	48½	48
Do. Preferred ... x d.	79¾,	80¼	80¼	79¾
Do. Deferred ...	17¾,	18¼	18¼	18
Brazil Submarine ...	11¾,	12	11 15-16	11 13-16
Cuba ...	10½,	11	10¾	—
Do. Preference ...	17½,	18½	17¾	—
Direct Spanish ...	5¼,	5¾	—	—
Do. Preference ...	15½,	16	—	—
Direct United States Cable ...	12¼,	12¾	12¾	12¾
Eastern Telegraph ... x d.	10¾,	10¾	10 15-16	10¾
Do. 6 per Cent. Preference ... x d.	12¾,	13	13¼	12 15-16
Do. 5 per Cent. Debentures, 1899 ...	105,	108	103	—
Eastern Extension ... x d.	11 9-16,	11 11-16	11¾	11½
German Union ...	9½,	10½	9¾	9½
Globe Telegraph and Trust Company.	7 7-16,	7 9-16	7 9-16	7 7-16
Do. Preference ...	12 15-16,	13 1-16	13	12¾
Great Northern ...	12¼,	12¾	12¾	12½
Indo-European ...	32,	33	—	—
Mediterranean Extension ...	1½,	2	—	—
Do. Preference ...	5½,	6½	—	—
Reuter's ...	9½,	10	—	—
Submarine ...	240,	250	249	246½
West India and Panama ...	1,	1¼	1 1-16	1
Do. 1st Preference ...	6½,	6¾	—	—
Western Brazilian ...	6,	6½	6½	6½
West. Union 7 per Cent. 1st Mortgage	122,	124	—	—
Do. 6 per Cent. Sterling Bonds ...	103,	106	105	104

TELEPHONES.

Consol. Telephone and Maintenance ...	¼,	½	—	—
Oriental ...	5-16,	7-16	⅜	7-16
United Telephone ...	9½,	9¾	9½	9½

ELECTRIC LIGHT.

Anglo-American Brush Lgt. (£7 paid).	3½,	3¾	3 9-16	3½
Do. (fully paid) ...	6,	7	10	—
Hammond Light ...	2,	2½	2 11-16	2½
Swan ...	2,	2½	2¼	2 1-16
Maxim-Weston ...	¼,	½	—	—

MISCELLANEOUS.

Telegraph Construction ...	34,	34½	34½	33¾
India Rubber, Gutta Percha, and Telegraph Works ...	30,	31	30¾	—

TRAFFIC RECEIPTS FOR JUNE, 1883.

COMPANIES.	June, 1883.	June, 1882.	Incrse.	Decrs.
Anglo-American Telegraph Company ...	—	—	—	—
Brazilian Submarine Company ...	—	—	—	—
Cuba Submarine Company ...	2,700	2,951	—	251
Direct Spanish Telegraph Company ...	1,552	1,963	—	411
Direct United States Cable Company ...	—	—	—	—
Eastern Telegraph Company ...	—	—	—	—
Eastern Extension Telegraph Company ...	34,307	31,122	3,185	—
Great Northern Telegraph Company ...	—	—	—	—
Submarine Telegraph Company ...	—	—	—	—
West Coast of America Telegraph Company	—	—	—	—
Western and Brazilian Telegraph Company ...	—	—	—	—

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NOTES.

IDLE (YORKS.).—The local board are inviting tenders for lighting the town with gas, electric light, oil, &c.

BOSTON, U.S.—Twenty Thomson-Houston electric lights have been placed in the Public Garden in Boston.

POSTAL TELEGRAPHS.—Mr. G. W. Corps, sorting clerk and telegraphist at Windsor, has been appointed postmaster of Yeovil.

TELEGRAPH CONNECTION WITH LIGHTSHIPS.—The Sunk lightship is to be at once put into telegraphic connection with the shore.

TILBURY DOCKS.—Both arc and incandescent lights are being used in the carrying out of these works by Messrs. Kirk and Randall.

NEW SOUTH WALES.—Mr. W. J. Trickett has accepted the Postmaster-Generalship on Mr. Wright's appointment as Minister for Public Works.

SIAM.—The Postmaster-General at Bankok is H.R.H. Sonditch Chow Fah Bhanuvaugse Swangwongse Krom Luong Bhanuphandhuwongse Voradej.

BUENOS AYRES.—We have before us the list of subscribers to the telephone exchange. The numbers increase rapidly, and the exchange seems in a flourishing condition.

UNDERGROUND MAINS IN PHILADELPHIA.—It is proposed to extend the wires already laid, and capital has been called up for this purpose by the Underground Electric Company.

THE RIVER PLATE TELEPHONE AND ELECTRIC LIGHT COMPANY.—The payment of a dividend of 9 per cent. per annum on the preferred shares to April 30th last is announced.

CHICAGO.—The authorities are still continuing their war against overhead wires used for arc lights. These wires are to be placed underground. Several overhead wires have been cut by the authorities.

THE WESTERN AND BRAZILIAN TELEGRAPH COMPANY.—The traffic receipts for the week ending July 20th, were £2,054, after deducting the "fifth" of the gross receipts payable to The London Platino-Brazilian Company.

THE DIRECT UNITED STATES CABLE COMPANY.—The final dividend for the year of five shillings per share is payable on and after the 16th August, making, with the interim dividends already paid, five per cent. for the year ending 30th June last.

FORGERY ON THE SOUTH EASTERN BRUSH COMPANY.—On Monday, Neville Hutchinson and Albert Mayor, in the employ of the South Eastern Brush Company, were charged at the Mansion House with forging cheques to a considerable amount. Both were remanded.

THE GREAT NORTHERN TELEGRAPH COMPANY.—The duplication of this company's cable from Wladiwostock to Nagasaki has just been completed, and the new cable has been opened for traffic. The duplication of the Nagasaki-Shanghai cable will be proceeded with forthwith.

TELEGRAPH EXTENSION IN AMERICA.—The Michigan Postal Telegraph Company is to have lines to Detroit and Chicago. This is an outgrowth of the New York and Postal Telegraph Company, and has just been incorporated with a capital of 50,000dols. Several branches will be operated.

CUBA SUBMARINE TELEGRAPH COMPANY.—The directors after providing for the dividend on the preference shares, and placing £3,262 to reserve, recommended the payment of a dividend on the ordinary shares of 9 per cent. per annum for the past half year, leaving £3,265 to be carried forward.

MORE EARTHQUAKES.—A shock of earthquake was felt last Tuesday morning in Oporto, and caused great consternation. Its direction was from east to west, the shock lasting only a couple of seconds. Two shocks of earthquakes are also reported to have occurred on the same day at Gilroy, California.

THE FISHERIES EXHIBITION.—The electric light appears to have added considerably to the attractiveness of this exhibition, no fewer than 26,351 persons having visited it on Saturday, making a total of 103,934 for last week. The attendance exceeds the most sanguine of the estimates made before the opening of the exhibition.

FOREIGN TELEGRAMS.—On the occasion of the Premier's speech relating to the Suez Canal, delivered on Monday week, there were more telegrams despatched from the House of Commons to the Continent than were ever known to be forwarded on any one evening before. The chief places of destination were Paris, Vienna, Constantinople, and St. Petersburg.

A GOODLY NUMBER OF PATENTS.—The Gramme Electrical Company, together with its members, the Brush, Edison, Fuller, Jablochkoff, Thomson-Houston, United States and Weston Companies, own or control nearly 500 patents, and will support these patents against all infringements. The mere list of patents fills about fourteen pages of a quarto pamphlet.

A NEW AMERICAN TELEGRAPH COMPANY.—The New York Underground Telegraph Company has filed its articles of incorporation. The company intend to run wires "under, over, and through the streets and avenues" of every town and city in the state of New York, provided the consent of the local authorities is first obtained. The company has a capital stock of 50,000dols.

ELECTRIC LIGHTING BY WATER-POWER.—A Brush-Swan Electric Light Company is being organised in Washington. It is intended to light both streets and houses by electricity, and to drive the dynamos by water-power from the canal, a mile above Georgetown, where a 500 horse-power turbine wheel will be placed. The power in the daytime will be utilised to charge storage batteries.

THE JABLOCHKOFF LIGHT.—Mr. R. Reeves, the secretary and general manager of the Jablochkoff Electric Light and Power Company, writes to the daily papers with reference to some remarks made by Mr. Pope, Q.C., before the Committee of the House of Commons, that the Jablochkoff Company is under contract to light Covent Garden Theatre and the Floral Hall, and that the Promenade Concerts will be so lighted this evening.

PERSONAL.—The following promotions and grants of leave in the Indian Telegraph Department are made from June 14:—A. J. L. Cappel, to be director-general; Lieut.-Col. H. A. Mallock, to be deputy director-general; W. R. Brooke, to be director; Lieut. J. B. Edwards, sixty days' leave; Lieut. W. H. Cornish, Meywar Bheel Corps, thirty days' leave; H. R. Rich, assistant superintendent (1st grade, Telegraph Department) is allowed twelve months' leave.

THE VIENNA ELECTRICAL EXHIBITION.—The Committee of Management who a few days ago postponed the opening of the International Electrical Exhibition indefinitely, have now announced that the ceremony will take place on the 16th inst. The British Commissioners have appointed Mr. F. H. Webb (Secretary of the Society of Telegraph Engineers and Electricians) as their secretary in London, and Lieutenant Ralph W. Anstruther, R.E., as their secretary in Vienna.

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American Electric Company.—At the meeting of the directors of the American Electric and Illuminating Company on the 10th July it was announced that amongst the plants which will be completed during the year are one of 1,000 lights in New York, one of 200 lights in Providence, one of 150 in Worcester, one of 300 in East Boston, Chelsea, Malden and Revere Beach (with central station at Chelsea), and one of 100 in Manchester, N.H. Other works were also mentioned.

British Honduras.—The question (says *Colonies and India*) of establishing external and internal telegraphic communication has been made the subject of a circular sent round to the colonists by the Governor. Hitherto there has been no telegraph erected in the country, and the want of it begins to be greatly felt. The construction of a line between Belize and Livingstone immediately will be strongly advocated. The Governor's circular referred to states that he believes with "judicious economy" the revenue of the colony will be amply sufficient to warrant the required expenditure.

Patents.—Lord Bury in his article in the July number of the *Nineteenth Century* has some excellent remarks on patents. Speaking of dynamos of the Gramme type, he says:—"They vary in details, and as a rule all the details are patented. It is very shrewdly suspected by some that patents have of late years so overlapped one another, and have been so infringed by everybody, that no patent is worth defending, and no patentee would dream of putting his patent to the test of a law suit. At any rate it is safe to believe that the excellence of electrical machines is now dependent on workmanship, and not on the possession of patent rights."

Holidays.—We may be allowed even in the midst of graver matters to call attention to the admirable Tourist Guide and Holiday Hand Books issued by the Great Eastern Railway Company. We can appreciate the information given in these little works, as we have frequently availed ourselves of the very excellent accommodation for travellers by the Great Eastern Company to Holland, Belgium, the Rhine, &c. The hand books are freely illustrated, and issued at the low price of one penny, the guide book being issued for sixpence. The latter, besides letterpress and illustrations, contains a good route map. No doubt the Amsterdam and Vienna Exhibitions will attract many by the Great Eastern route, and they will find the vessels to Rotterdam and Antwerp among the best, if not the best, to the Continent.

Telegraph Learners.—We understand that at the examination which took place before the Civil Service Commissioners in the first week of July, when about thirteen hundred candidates presented themselves for the preliminary ordeal, barely one hundred succeeded in passing it. As there were only one hundred vacancies, the final competitive examination has had to be dispensed with, and the successful hundred have been informed that they will be passed without further test. The preliminary examination consisted merely of writing from dictation, and easy sums in the first four rules. For the competitive examination it was contemplated extending the arithmetic subject to vulgar and decimal fractions; but this, of course, has been abandoned in order not to diminish the number of candidates still further.

Legal.—Mr. Gully, Q.C. (with whom was Mr. Henn Collins), moved for a rule nisi for a new trial in the case of Muir and Co. *v.* Anglo-American Brush Electric Light Company, on the ground that the verdict, which had been for the plaintiffs for £736, was against the weight of evidence, and also on the ground of misdirection by the learned judge (Mr. Justice Pearson) before whom and a special jury the hearing took place at Manchester on the 23rd ult. The plaintiffs are engineers there, and they brought their action to recover damages for the non-acceptance of a special boring and facing dynamo-machine. The defendants, finding the machine was not delivered for many months after they had given their order for it, had written to the plaintiffs in May last refusing to take it on the ground of the delay. The verdict was given in favour of the plaintiffs, inasmuch as the time taken in the construction of such a machine was not inordinate. The machine was necessarily of a new design, and very complicated. The Court granted a rule nisi for a new trial.

The Electric Light in South London.—On Saturday Mr. T. J. Dunham, the vestry clerk of St. Mary, Newington, received from the Board of Trade an official copy of Major Marindin's report with respect to the vestry's application for a license to light a portion of the parish by electricity. The report is the result of a public inquiry held by order of the Board of Trade at the Vestry Hall, Walworth-road, a few days ago. After summarising the evidence given for and against the scheme, Major Marindin concludes as follows:—"It is proved beyond a doubt that the scheme, although in itself apparently well considered and likely to be successful, does not commend itself to the large majority of the ratepayers of the parish. In my opinion a question such as this, involving the expenditure of a considerable sum of money upon an undertaking which in the present time may fairly be termed speculative, and necessitating an addition to the rates in a poor parish, already heavily taxed, should not be finally settled except by a very large majority of the representatives of the ratepayers, and, where it can be ascertained, by the approving voice of the ratepayers themselves. I have therefore to recommend that the application for a license be not acceded to." This result was mentioned before the Select Committee on the previous day.

Products from Telegraph Batteries.—"Of the £12,350 spent during the year 1881-82 upon the 127,166 galvanic cells in use, £2,727, or about 22 per cent., was recovered by the sale of the battery residues, consisting of copper, zinc, and lead salts. It has been customary," says the *Scientific American*, "to sell these products by auction twice a year. The Government does not guarantee any fixed percentage of metal in these salts, but the amount varies very slightly. The normal cell of the German telegraph offices is a modified Daniell cell of a simple and cheap kind. The zinc electrode is formed of a ring, hanging down from the edge of a glass vessel to half its depth. On the bottom lies a rectangular plate of lead, to which a vertical stout iron wire, encased in sheet lead, is soldered, making the other electrode. The glass is filled with sulphate of zinc solution, and a few crystals of sulphate of copper are from time to time dropped into the liquid. Of these materials the zinc is, of course, most subject to deterioration. Thus we find that the above-mentioned 127,166 cells required nearly 80,000 new zinc rings, against 7,300 lead sheets and 910 lead plates. The sulphate of copper forms the largest item in the annual expenditure, amounting to £8,000. During the four years which the table comprises, from 1878 to 1882, the number of cells had increased by nearly 20,000."

The French Government and the Tonquin Cable.—A discussion took place in the Senate on Wednesday evening relating to the connection of Saigon with Tonquin by a submarine cable. M. Blancsube, the Cochin China Deputy, exhorted the Chamber not to ratify the Convention passed by the Government with the English Eastern Extension Com-

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pany for the laying of the cable in question. Every one must approve the project, but no one could approve the installation of an English company in a region that had become French. The Government, it was true, stipulated that half the *employés* should be French; but such a guarantee was absolutely illusory, and would not prevent breaches of confidence. The Minister of Marine had, more than once, had proof that the English were acquainted with his cipher. The Colony of Cochin China had offered for itself and Tonquin to pay half the subvention and to advance one-fourth the cost of providing and fixing the cable. A cable on French soil must be be French. The Minister of Marine, in reply, said the English company had offered far better conditions than the colony. All the conditions of the arrangement had been closely scrutinised, and the Government must maintain their proposal. The Chamber divided, when the Government Bill was rejected by a majority of 218 to 183. The announcement of the numbers was received with cheers, mingled with expressions of disapproval. M. Blancsube laid upon the table a motion for the establishment of a French cable between Cochin China and Tonquin. This was sent to the committee.

The First Electric Locomotive.—"*Apropos* of various claims," says the *Electrical World*, "for the distinction of having invented the first electric locomotive, a writer in the Baltimore *Sun* recalls the experiments of Dr. Charles Grafton Page, who was born at Salem, Mass., on January 28, 1812, and died in Washington, D.C., on May 5, 1868." 'He constructed an electrical machine when only ten years of age,' says the writer in the *Sun*, 'and graduated at Harvard University in 1832. In 1838-40 he practised medicine in Virginia, and in 1839-40 filled the chair of professor of chemistry in Columbia College, in the district of Columbia. In 1840 he was appointed examiner in the United States Patent Office, which office he held until his death. He was a frequent contributor to *Silliman's Journal*, and is the author of a concise and complete treatise upon the subject of electrical science and discovery. He had been for years perfecting machinery for the effective and economical use of electro-magnetism as a motive power, and had so far succeeded as to be able to use it for the propulsion of machinery, and as a locomotive force. In 1851 he constructed at Washington a locomotive to run by electricity, and at its first trial, on April 29 of the same year, on the Washington Branch of the Baltimore and Ohio Railroad, it more than exceeded the expectation of the inventor, though many difficulties were encountered in matters of detail. The trip was made from Washington to Bladensburg in thirty-nine minutes, including five stops, and the greatest speed attained was at the rate of nineteen miles an hour.'"

The Electric Wonders of the Age.—The Hon. S. S. Cox, in the annual address delivered before the Indiana Asbury University, said:—"The electric monograph transmits messages in the original handwriting, the hektograph multiplies your epistles, the telephone enables people to make contracts through an orifice; but, as there is no witness, photography comes in and records the shadow of the sound by curves in vowels and consonants! Electricity is an element elusive and subtle, yet it is stored in a box and imprisoned in a metal, to be used at pleasure for portraiture, sound, light, or power. I have seen an organ in Berlin played by electricity; but this is simple compared with other experiments. Is it not a marvel that we can telegraph from a moving railroad car or the speeding steamship? A California photographer obtains six photographs in one leap of a clown in six different positions. He catches a horse on the gallop, a rabbit on a run, and a bird on the wing. By means of a wire a circular saw or a locomotive may be—nay, has been—run miles distant from its source of force. Electricity is born of the sun. It may be converted back to its source, so that when one talks by telephone he may see his distant colloquist. It is shrewdly believed that nerve power depends for increased strength on light. It will not be strange if the polyscope illuminates the animal organism, rendering the body transparent. The vast current of liquid force which we call electricity is condensed in boxes like dessicated meats, or spread over continents to convey intelligence. Man can never overdraw from this vast, bankruptless depository of nature." We should fancy that the hon. gentleman who talks like this understands very little of his subject.

Storing Wind Power.—The *Scientific American* recently contained an article directing the attention of inventors to design some means of storing wind power. This article briefly referred to the method of charging secondary batteries by this means. In the following issue another article pointed out that such storage was at present out of the question. Thus we read:—"What storage batteries may eventually be brought to do is entirely uncertain. The whole subject of the actual management of electricity, so that it shall be an agent for mechanical uses, safe, trustworthy, and cheap, is yet so little understood that, though we have great hopes for the future, our use of it at the present is subject to much difficulty. As to storage batteries, in any of the various forms in which they have been made, and bearing the names of different inventors, it is but fair to remember that the accounts which have been published have been chiefly those put forth by interested parties, those who had pecuniary interests involved; and, without imputing any intentional deception, it is easy to understand that such statements may go further than practical working will warrant. The batteries are in truth of small real value. No man would dare to depend on them as a means of carrying on work whose success required a steady and even power. In the first place, they are very wasteful, for the claims made of the great percentage of power recovered from them are certainly not borne out, when they are subjected to fair investigation by those who have no object in proving their great excellence. It is not too much to say, in general terms, that very nearly half the power transmitted to them is not recovered. Then, again, trials seem to indicate that their life is short. The constant chemical action disintegrates the plates so rapidly that very frequent renewal is necessary. This, it is true, may not be very expensive, but it is very troublesome. And it is evident that until, or unless, they can be greatly changed and improved they will not do what we need in this case."

Another Electrical Tramcar.—Some interesting experiments have been made at Halifax, Yorkshire, with a novel method of propelling tramcars by means of electricity, the invention of Mr. M. H. Smith, C.E. Mr. Smith, instead of using the tram rails as the electric conductor, forms a channel up the centre of the track similar to that used in the Hallidie cable system. The electric conductors are placed upon insulators in the channel, thus avoiding the defect and danger of making the rails the electric conductors. A little carriage runs upon the conductors in Mr. Smith's system, provided with collectors—plates passed through the longitudinal opening or slit in the surface—and copper wires carry the current to the electric engine on the car. In the matter of wheels there is also a departure from the usual method. Instead of using only the little wheels running upon the rails, a large wheel with a broad yielding surface runs in the middle of the track, thus ensuring smooth tractive force, and enabling a light engine to do more work.

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Stopping and starting the car is done by an electric switch connected to frictional gear, and, judging by the experiments made, it seems to answer effectively. The tramway is laid down in the grounds at Moor Side, the residence of Mr. L. J. Crossley. The electric force is generated by means of a small gas engine connected with a Gramme machine, which Mr. Crossley uses in his private workshop. So far as the invention has been tested it appears satisfactory, though, no doubt, improvements in certain minor details have yet to be effected. The gradient is a moderate one. We should be glad to hear of the application of Mr. Smith's system on a larger scale, for one of the greatest dangers in the present system, as applied at Berlin and Vienna, at Portrush, in Ireland, and elsewhere, is this, that if a horse placed a foot on each rail when the latter are the electric conductors, it would receive a fatal shock. On the other hand, a passing vehicle would short-circuit the current and stop the car.—*Iron.*

The Strike of American Telegraphists.—The first signs of victory for either party to this unfortunate dispute appeared on the day we went to press last week. The American Rapid Telegraph Company, one of the smaller companies affected by the strike, conceded the main demands of the operators, excepting upon the question of wages. The men asked for a 15 per cent. advance, and a 10 per cent. advance was granted. The company's lines extend through New England and the central States. It already receives plenty of business, thus relieving the pressure. The public was becoming restive under the delays in the transmission of messages. The strikers are jubilant; but it is generally believed that this company has compromised only after coming to a secret understanding with the other companies, in order to clear off some of the arrears. The situation of affairs on the Western Union lines is unchanged. Various suits have been commenced against the company for damages, on telegrams being declined by it in consequence of the intending senders refusing to sign the agreement referring to possible delays. The Great North Western Company, which is working the Canadian lines, announces that it is now working satisfactorily, and is everywhere independent of the strikers. The telegraph service, on the whole, shows some improvement. The general expectation is that the Western Union Company will ultimately come to some agreement with the operators. The American Rapid Company now has 400 operators at work. The operators of the Bell Telephone Company have asked for an increase of pay. The above intelligence describes the state of affairs down to the 27th ult., the other companies, including the Western Union, still holding out. The Western Union Company continued to threaten to fight to the bitter end, but it is generally understood that this is nothing but brag, as they can never afford to see their business steadily absorbed by their whilom confederates. Their obstinacy may prolong the dispute, perhaps, another week, but the powerful organisation of the operators, the temperate manner in which they have all along advocated their cause, and the entire absence of any outrage, or even attempt at intimidation, have won the admiration of the public, and will, it is thought, ensure their ultimate and complete success. The Western Union Company, furthermore, cannot well hope to starve out the strikers, inasmuch as 800,000 "knights of labour" have guaranteed to support the operators until Christmas, if need be. On Sunday *The Times* Philadelphia correspondent telegraphed that the situation remained unchanged as regards the strikers and their employers; but that the speed of transmission of telegrams steadily improved. Six English operators had arrived in New York, and were working in the Western Union Office there. The same correspondent says that on Tuesday the telegraph service continued to improve, and public interest in the strike was waning.

The Earthquake at Ischia.—The Island of Ischia, situated twenty miles off Naples, was visited by a severe earthquake on Saturday last at 9:30 p.m., when the town of Casamicciola was almost completely destroyed, a vast number of persons, estimated variously between three thousand and five thousand, having been buried beneath the ruins, and several hundred more severely injured. The shock extended to the neighbouring villages of Forio and Lacco, which were completely destroyed. The disaster of March, 1881, was nothing in comparison with this, which came with a sudden irresistible violence accompanied by a deafening noise. The first indication of the coming disturbance, according to the evidence of several survivors, was by a low, threatening, rumbling noise, which presently burst forth into one fearful roar, as though heavy artillery were being continuously fired in the immediate vicinity. In the next second the houses were rocked about and shaken into fragments. For fifteen seconds the earth was tossed about by upheavals in all directions. According to Professor Palmieri, of the Vesuvius Observatory, the disaster was not due to an earthquake, but to a subsidence of the ground. It is pointed out, however, as significant that Vesuvius had been unusually active just before the shock, and this fact taken in connection with the subsequent atmospheric disturbance seems to tell against the theory of Professor Palmieri. The previous weather had been splendid, but a violent storm set in the day following the disaster, and this, accompanied as it was by almost total darkness, added greatly to the horror of the scene, and rendered transit from the island to the mainland very difficult. —On Monday there was another slight shock experienced at Ischia, and two guards were killed.—On Tuesday the hot springs, which had been closed up by the *débris*, burst forth again with extraordinary violence, and at almost boiling temperature. Mount Vesuvius had developed into a state of active eruption, lava descending in the direction of Torre del Greco. It is now alleged that a slight premonitory shock was felt at Ischia on the 24th, four days before the final catastrophe. The loss of life is certified at between four and five thousand, and so complete is the ruin of the town that comparatively few of the bodies supposed to be buried can be recovered. Casamicciola is now one vast cemetery. Eye-witnesses state that the evening was calm, the sky cloudless and studded with stars, and the sea like a mirror—not a breath of air stirring. On Wednesday another slight shock was felt, but caused no further damage. In reference to this subject some interesting letters from our esteemed correspondent, Mr. W. G. Forster, of Zante, may now be re-read with profit. They appeared in *The Electrician*, May 14, 1881, and April 28 of the present year.

Electric Lighting of the Strand District.—The contention of several electric lighting companies for the lighting of the Strand District was continued on Monday before the Committee of the House of Commons, presided over by Mr. Sclater-Booth. Mr. Bidder submitted on behalf of the St. James's Vestry and the Telegraph Construction and Maintenance Company that it would be unfair to the former to subject the district for twenty-one years to companies who would charge 50 per cent. more than the company he represented.—Mr. Pope, on behalf of the Swan and Edison Companies, argued that the exclusion of the former and the admission of the Jablochkoff would keep back the lighting of theatres for an indefinite period. The theatres

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would be large consumers, because they could afford to pay a high price for an electric light, which would prove attractive to their audiences. The arguments for the respective parties being concluded, the room was cleared, and the committee remained for some time in deliberation. On the re-admission of the public, the chairman announced that the committee had agreed to pass the Edison order subject to certain alterations. They desired that the Edison district should be extended so as to cover the whole parish of St. Martin, and to include the whole of Covent Garden. They desired the Edison Company to be in the eastern Strand district, for the purpose of generating electricity only—the price to be the same as the Swan, 8d. instead of 9d. Subject to these alterations the Swan order would be passed. Clause 67, enabling the Jablochkoff Company to apply for a license, was struck out. The result is that the lighting of the Strand district is divided between the Swan and Edison Companies. The Westminster district was struck out.—This subject coming before the House of Commons on Wednesday, Mr. W. H. Smith said he understood that some amendments had been introduced into the Bill by the Select Committee, and that the Strand Board objected to the inclusion of their district within the order made in May last and passed by the committee. Therefore he wished to ask the President of the Board of Trade whether he would consent to the omission of the Strand district from the present order.—Sir G. Campbell said the local authority of Kensington had not consented to the provisional order, and asked for three months' delay.—Mr. Chamberlain observed that three months' delay meant postponement for another Session. The Board of Trade had carefully gone into the whole question, and he was glad to say that, in very nearly all cases, these orders had been assented to by the parties concerned. With regard to Kensington, the committee had made no alteration in the order as originally drawn, and he was surprised at the persistent opposition of the hon. member (Sir G. Campbell). He denied that the action of the Board of Trade was despotic; they were only acting as servants of the State in carrying out the powers entrusted to them under the Act of last Session. —After some discussion the Bill was considered.

Duration and Brightness of Lightning Flashes.—Mr. R. A. Proctor contributes the following to the *Newcastle Chronicle* on these subjects :—"During the recent thunderstorms good opportunities have been afforded of testing by experiment the duration of a lightning flash. This can be done in a rough and ready manner easily enough when a thunderstorm is in progress at night, though the determination of the precise limit of duration of course requires a much more careful arrangement. Let a black disc be prepared, at the edge of which are a number of very fine radiating streaks of white of definite breadth, say, for instance, that at the very edge the white streaks are exactly equal in breadth to the spaces between them. Now let this disc be so mounted that it can be set in very rapid rotation at a measured rate, say, for instance, ten times in a second (though a hundred times in a second will be better) and kept in such rotation steadily for ten or twelve times the average interval between the flashes. Let this instrument be so placed as to face the region where the lightning flashes are seen, and so that it cannot be seen except by the lightning's light. Then let it be set rotating, and the eye directed towards it until the lightning illuminates it. Presently a flash will occur, and the disc will be illuminated. It will seem that the rotating disc is absolutely at rest. Not only will the streaks seem unmoving, but the breadth of the white streaks will seem to bear precisely the same proportion to the breadth of the dark spaces between them as when the disc was examined while at rest. Let us consider what this means. Suppose the disc is rotating ten times in a second; then, if a lightning flash lasted one-tenth of a second, the disc would make one complete circuit in that time, and the eye would see the streaked part near the edge as a grey ring, no trace whatever of the separate streaks being seen; but a much shorter duration of the flash would produce a complete blending of the streaks and spaces. If there are 400 streaks, and the flash lasts the 4,000th part of a second, each streak will be carried into the place of the next streak while the flash is still illuminating the disc, and no trace even of any difference of illumination could be recognised. If the flash lasts the 8,000th part of a second each streak will be carried into the place of the next dark streak while the flash still illuminates the disc, and though a marked difference of illumination might be recognised every part of the disc would seem more or less illuminated. A much shorter duration even than this, however, would show an observable difference in the apparent breadth of the bright streaks—a blurring of their edges, so to speak. If the flash lasted the 100,000th part of a second the streaks would be widened a twelfth part and the intermediate spaces would be narrowed a twelfth, so that their relative breadths, instead of being equal, would be as 13 to 11, or the bright streaks about a sixth wider than the dark ones. Now, for precise experiments, it is easy to get a much more rapid rate of rotation than 10 per second, and to have many more than 100 radial streaks per quadrant. On a black ebony disc, a foot in diameter, with a circumference, therefore, of nearly 40in., it is easy to inlay 4,000 silver threads radially near the edge. This would be only 100 per inch, and 200 per inch could easily be set in. With 100 rotations per second and 4,000 radial threads, the numbers just obtained would be increased a hundredfold, so that if no trace of blurring could be recognised—no perceptible widening of the streaks—it would follow that the lightning flash does not last the ten millionth part of a second. Such observations have been made, and the duration of a lightning flash has been shown to be in a great number of cases so short as to be beyond measurement even by this refined method—the invention, not of Foucault, to whom it has been erroneously ascribed, but of our own Wheatstone. Thus it has been shown that in reality a lightning flash is much brighter than it seems to be. For we see the flash by means of an instrument which will not deal with such short periods of time as the millionth or ten millionth part of a second. The light really shining for, say, the millionth part of a second is, as it were, diluted by being spread over about the tenth of a second, which is the shortest time in which the eye can take cognisance of it. Now, the eye is an integrating instrument in this case, showing us the total light received in the time during which the eye seems to be receiving light, and therefore giving the average illumination for that time. Thus the apparent lustre of a lightning flash lasting a millionth part of a second, but visible for the tenth of a second, is about the 100,000th part of its real lustre. If, instead of a single flash, a succession of flashes could pass in rapid succession along the same track, we should see forked lightning streaks as bright as the electric light along their whole length. As it is, the flash illuminates a whole landscape, and often its reflection can be recognised for tens of miles from the place where the storm is in progress. But in the case supposed the illumination, a hundred thousand times greater (if the flash were continuous), would produce a light comparable with or even surpassing that of daylight."

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ON THE COST OF ELECTRIC STREET MAINS.

BY GISBERT KAPP.

The cost of a system of electric mains with their branches, house service lines, test boxes, service boxes, connections, safety fuses, and poles on the consumer's premises depends so much upon local conditions that the task of establishing any sort of mathematical formula for it might at first sight seem almost hopeless.

The difficulty is further increased by the absence of data from actual practice, for no large and complete system of electrical distribution has as yet been established in England. Yet electricians are daily called upon to furnish plans and estimates for street mains, and by carefully taking into account all the details of each particular system of distribution they can certainly get as near to the real cost as in other large engineering works. But this is a laborious process, and for rough preliminary estimates a simple and easily-remembered formula would be very desirable.

I have found the following to agree fairly well with estimates worked out in detail:—

$$\text{Cost} = \frac{a\,R^2\,n}{p\,E^2}.$$

In this formula a is a co-efficient varying between 0·9 and 1·2, R is the maximum distance to which the supply has to be brought, n is the number of lamps, p the percentage of variation in pressure between station and the most distant point, and E is the pressure.

In order to justify this formula, it will be necessary to consider in what manner the cost is affected if the different values be varied separately.

Suppose we keep all the items constant, but double the number of lamps in the district, then double the current will have to be supplied, and this will need double the cross-sectional area in the mains, and, as cables or solid rods above a certain diameter cannot well be handled, this means duplicating the mains. Hence the cost is proportional to the number of lamps.

Now, suppose we wish to spread the same number of lamps over a longer distance. The length of mains must consequently be increased, and if their resistance is to remain the same their cross-sectional area must also be increased in the same proportion, hence their weight and cost increase as the square of the distance.

The difference in pressure between the lamps nearest and those farthest from the station is directly as the current flowing, and inversely as the conductivity of the whole system.

If we allow this difference to increase by a certain amount we can either feed a proportionately larger number of lamps or reduce the cross section and weight of mains in proportion.

The cost is therefore inversely as the per centage of variation allowed.

Now, as to variation in the electromotive force or pressure employed. The higher the pressure the less current will be required, whilst at the same time the loss of pressure in the mains can be increased. The weight and cost of mains varies, therefore, inversely as the square of the pressure.

As regards the co-efficient a, this depends upon how the lamps are distributed throughout the district. It is hardly probable that the lamps will have to be distributed with perfect evenness throughout the whole of the district, but we may take this to be the extreme, and at the same time the most unfavourable case as regards cost.

Generally there will be one quarter in the district where the number of lamps per unit area is a maximum, and, if possible, the station ought to be placed in the middle of that quarter.

Should it be absolutely necessary to place the station at a considerable distance, then separate feeding mains will have to be carried into the middle of this district, and the current supplied from the terminals of these mains as if from a station. The cost of these mains is not included in the formula. In either case the distribution will be made from a centre situated in the middle of the most densely lighted portion of the district, and this can be regarded as the other extreme, and at the same time most favourable case, as regards cost.

It can be represented by assuming that the number of lamps per unit length of mains radiating from the centre is a constant.

Let, in Fig. 1, S be the station, and S A one of the mains radiating from it, and represent the amount of current which is drawn off to the right and to the left of the radial main per unit length by the lines $s\,s$, $s_1\,s_1$, $a\,a$, then the area of rectangle $s\,s\,a\,a$ represents the total current supplied to that

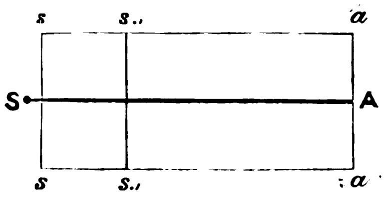

Fig. 1.

portion of the district which is fed through the main S A. Let C be that current, ρ the resistance of main per unit length, and l the length of main, then we find the difference in pressure between S and A by the formula

$$p = \frac{1}{2}\,C\,\rho\,l^*.$$

Now, in the other extreme case, where the number of lamps per unit area is a constant, the area which represents the total current supplied to the district will be that of the triangle S a a, Fig. 2, and the current flowing past point X at

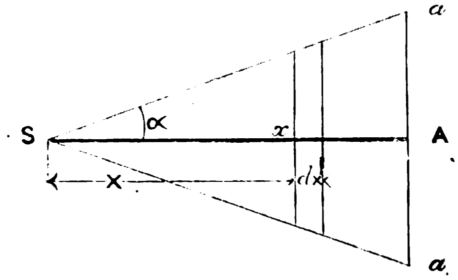

Fig. 2.

distance x from the station is $(l^2 - x^2)$ tang. α, l^2 tang. α being the total current C. The loss of pressure in the distance $d\,x$ is therefore $d\,p = (l^2 - x^2)$ tang. $\alpha\,\rho\,d\,x$, and this integrated between the limits $x = o$ and $x = l$ gives the total loss between S and A

$$p = \frac{2}{3}C\,\rho\,l,$$

or, 1·33 times as great as in the former case. From this it follows that in the case where the number of lamps per unit area throughout the district is a constant, the cost of mains will be by 33 per cent. greater than in the case where the number of lamps per unit length of radial main is a constant. The co-efficient a must therefore vary between these extreme limits 1 : 1·33 :: 0·9 : 1·2.

If R be given in units of 100 yards, E in units of 100 volts, and p in per cents., the total cost of the distributing plant in pounds comes to

$$£ = \frac{0{\cdot}9\,R^2\,n}{p\,E^2},$$

if the number of lamps per unit length of radial main is constant, or to

$$£ = \frac{1{\cdot}2\,R^2\,n}{p\,E^2},$$

if the number of lamps per unit area of district served is constant.

Take as an example an installation of 60,000 lamps, covering an area of half a square mile. If the station can be placed in the centre of the district this gives R = 7·00.

Allow the full variation of five per cent. up and down per-

* See *Electrician*, No. 4, Vol. X.

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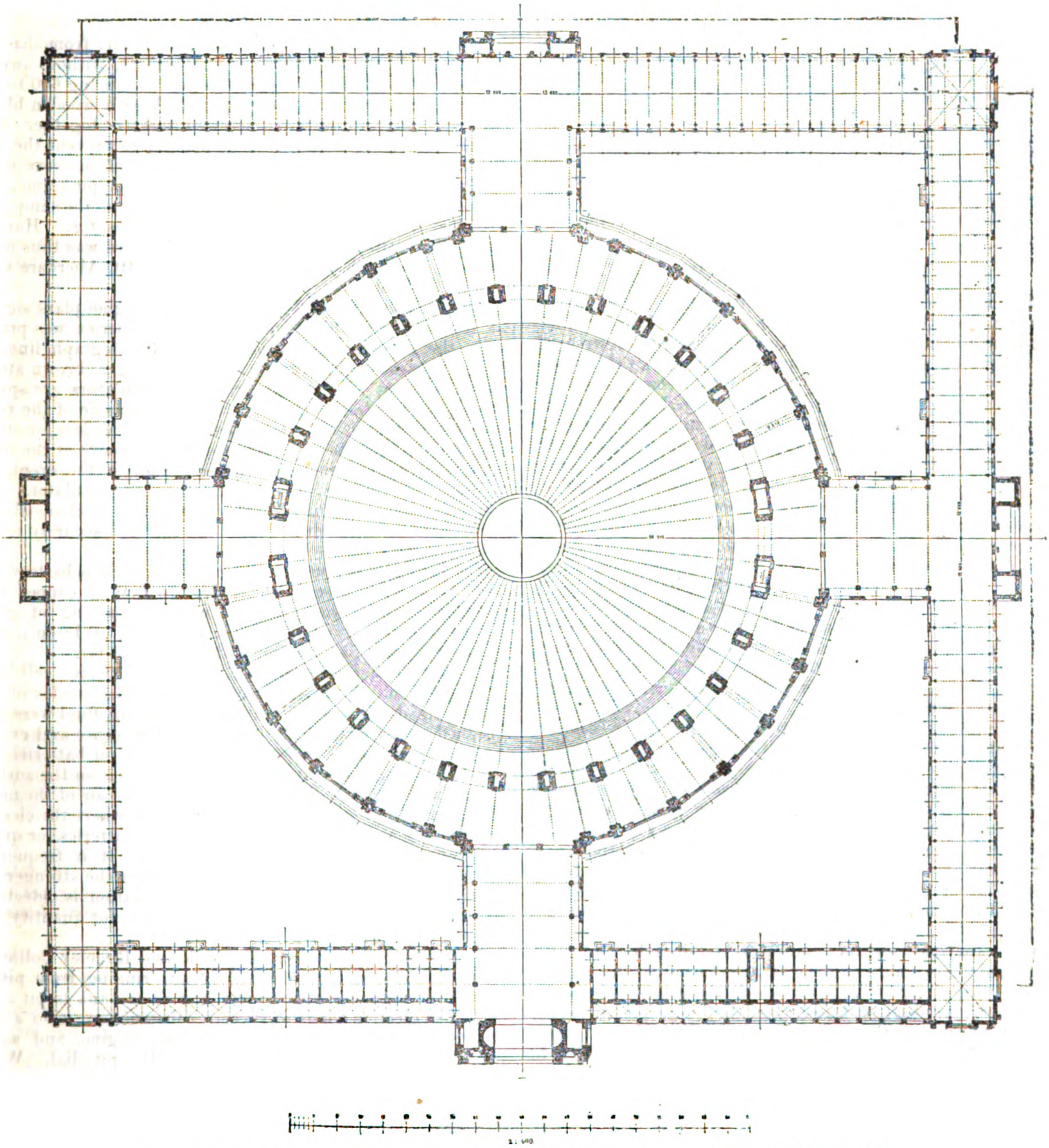
mitted by the Electric Lighting Act, and assume the pressure to be fixed at 140 volts, then the cost of this plant will be

$$\frac{0{\cdot}9 \times 7^2 \times 60{,}000}{10 \times 1{\cdot}4^2} = \text{about } £135{,}000,$$

or,

$$\frac{1{\cdot}2 \times 7^2 \times 60{,}000}{10 \times 1{\cdot}4^2} = \text{about } £180{,}000,$$

for the sum of £220,000 is so great that I cannot pass it over in silence. Either the above formula is altogether wrong, or the 60,000 lights were meant to be crowded into a circle of about 600 yards diameter, in which case the distribution, even at the low potential of 70 volts, could very nicely be done for £100,000, leaving £120,000 for the generating plant. As regards the correctness of the formula the co-efficients 0·9 and 1·2 have to be obtained from comparison with various



THE VIENNA ELECTRICAL EXHIBITION.--PLAN OF BUILDING.

according as the lamps are more or less favourably distributed.

At 70 volts pressure, the cost of mains would be four times; at 200 volts it would only be half as much.

The discrepancy between these figures and the famous Nottingham tender, in which the Telegraph Construction and Maintenance Company offered to supply distributing and generating plant sufficient to feed 60,000 twenty-candle lamps

estimates which have been carefully worked out in detail, and by going through the same process the reader can easily check them. Such items as the kind of paving to be broken open and made good again, or the number of gas, water, and other pipes, or the number of sewers to be dodged will naturally influence the cost, and therefore the formula can only give a rough approximation.

But for a preliminary estimate, even if it have a possible

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error of from 10 per cent. to 20 per cent., the formula will be found useful.

Where the station is not approximately equi-distant from all parts of the limits of the district, the latter should be subdivided into sections, and the cost of mains calculated separately for each sector.

ON THE APPLICATION OF ELECTRICITY TO THE WORKING OF COAL MINES.*

BY MR. ALAN C. BAGOT, OF LONDON.

The writer proposes to divide this subject into two heads, as follows:—

(I.) The application of electricity to signalling purposes.

(II.) The more recent application of powerful electric currents for the purpose of illumination, or of transmission, or storage of power, both on the surface and within the workings of the mine itself.

I. *Electric Signalling in Mines.*

The increased depth of the shafts of collieries in this country, and the introduction of rapid winding gear, have rendered the method of mechanical signalling known as the "hammer and plate" system quite obsolete. By this system the only signals that could be exchanged between the cager, or man at the bottom of the shaft employed in loading tubs on the cage, and the banksman, or man in charge of the surface and engine room, were produced by pulling a wire attached to a hammer, which knocked its signals on a piece of boiler iron. This caused great loss of time and unnecessary labour, as well as some danger, on account of the lapse of time between each signal. Again, the wire frequently broke, causing risk to those employed in getting the broken part out of the shaft, and very serious delay when the pit was drawing coal. The result of such a break is to fill the road going "out bye," or to the pit bottom, with loaded tubs that cannot be drawn up till the signals are repaired. Consequently no empty tubs are available to be taken in to the working faces where the men are getting coal. The loss of time thus caused is very much greater than would be supposed at first sight.

The writer's experience further shows that, in cases of accident traced to defective signalling, contradictory explanations were generally offered by those in charge of the signalling appliances. Again, in the case of inclined planes underground, driven by an engine on the surface, unless the latter can be signalled to stop instantly from any part of the road, fatal accidents will be of such frequent occurrence as to render any extensive scheme for such haulage a matter of grave responsibility to the manager, and of great and unnecessary risk to the men. A further source of danger was present in foggy weather, where the engine driver had nothing to guide him but the shaft distance indicator, required by the Mines Regulation Act; nor could he at any time tell the position of the "kips" or bolts upon which the cages rest when at the top of the shaft, or know when they were pulled back to allow him to lower the cage down the pit.

In 1874 the writer determined on using electricity for signalling purposes; and from thence to 1877 he carried on a series of experiments in different shafts with a view to determine whether insulated cables, naked copper wire, stranded copper or iron wire, or galvanised iron telegraph wire, was the most suitable conductor for conveying the current in the shafts. The result of trials in several different districts showed that insulated cables were too expensive in the first instance, and also were practically useless, being stripped and destroyed by falling coal from the cages, &c., and especially liable to electrical leakage. What was still worse, they were subject to a form of back charge, due no doubt to the coating of coal dust which adhered to the sheath of the cable. Further, their position did not allow of their being readily tested or inspected; and unnecessary delay took place in finding disconnections and other electrical faults, when the cable was not manifestly disturbed or injured. Stranded iron wire was found too prone to rust, and of too high an electrical resistance; stranded copper wire too heavy; solid copper wire too soft, and apt to draw out. No. 11 galvanised-iron telegraph wire (0·120in.) was too light, and of too high a resistance for either shafts or engine planes. Finally, No. 4 (0·238in.) galvanised-iron telegraph wire was found most suited for shaft conductors, and No. 8 (0·165in.) for engine planes.

The shaft conductors were hung vertically from shackles on the pit-frame to the bottom of the shaft, without any intermediate support, the depth in some cases being 600 to 700 yards. The conductors were provided with wooden blocks on each side of the wire, screwed tightly together with thumb-screws, to act as safety clips, and to prevent the wire from falling down the shaft in the event of an overwind or explosion carrying away the shackles on the pit-frame. To the lower end of each wire, which hung free in the sump, was attached a 20lb. weight to act as compensator. Harris's Deep Navigation Colliery at Quaker's Yard was thus fitted in 1880, the depth of the south pit to the 4ft. Aberdare seam being 695 yards.

The arrangement of No. 8 wire for the engine-plane signals at Risca, North Dunraven, and other collieries, was practically the same as an ordinary overhead-telegraph line, the special shackle found most suitable being a brown stoneware insulator. For a single road the insulators are spiked at suitable distances into the props on one side of the road, and for a double road into the overhead collars or crosstimbers. The line wire passes over the groove of the insulator, and is prevented from running back in the event of a break by a binding wire passing round the insulator. The binding wire used for this purpose is No. 16 charcoal-iron wire (0·065in.), which is bound and soldered securely round the line wire.

The insulated copper connecting-wires, such as battery and instrument wires, were made of No. 16 B.W.G. copper wire (0·065in.), which was insulated with a covering of gutta percha, making it equal to No. 7 B.W.G. (0·180in.), then wound with tape, and tarred with Stockholm tar.

The batteries found most suitable were twelve cell large size Leclanché batteries; the outsides and the insides of the glass cells down to the level of the exciting fluid were well brushed with paraffin oil to prevent efflorescence and evaporation. The evil effect of coal-dust in the pit batteries was avoided by pouring a little common engine-oil on the surface of the exciting fluid, thus sealing it from the air of the mine. Great advantage was derived in wet shafts, where the electric leakage was great, by duplicating the pit batteries for quantity, and thus keeping the tension low. It is frequently assumed that the greater the battery power the stronger the signals. This is not the case where insulation is defective; the remedy lies in coupling up more cells for quantity and keeping the tension low.

The system employed at Cannock and Rugeley Collieries consisted of a single-stroke bell circuit, ringing from pit to bank and engine simultaneously, and from bank to pit only, on 9-inch electric gongs of special construction; also a 12-order dial circuit from pit to bank and engine, and again from bank through the engine dial to the pit dial. When winding coal, the banksman, using the bell circuit only, rang twice to the cager as soon as he had taken off the full tub and put an empty one on the cage. The cager, having received the signal that the banksman had completed his operations, and having also himself taken off the empty tub and put on a full one at the pit bottom, signalled twice to bank and engine simultaneously, thus warning the banksman that he had signalled the engine-driver to start. In practice this has been found far safer and quicker than the prevailing custom of the banksman starting the engine-driver. For the purpose of signalling the driver to stop, the banksman was provided with a local bell circuit from bank to engine only; but in all cases, except when the sinkers were in the pit, the starting signal was taken from the cager only.

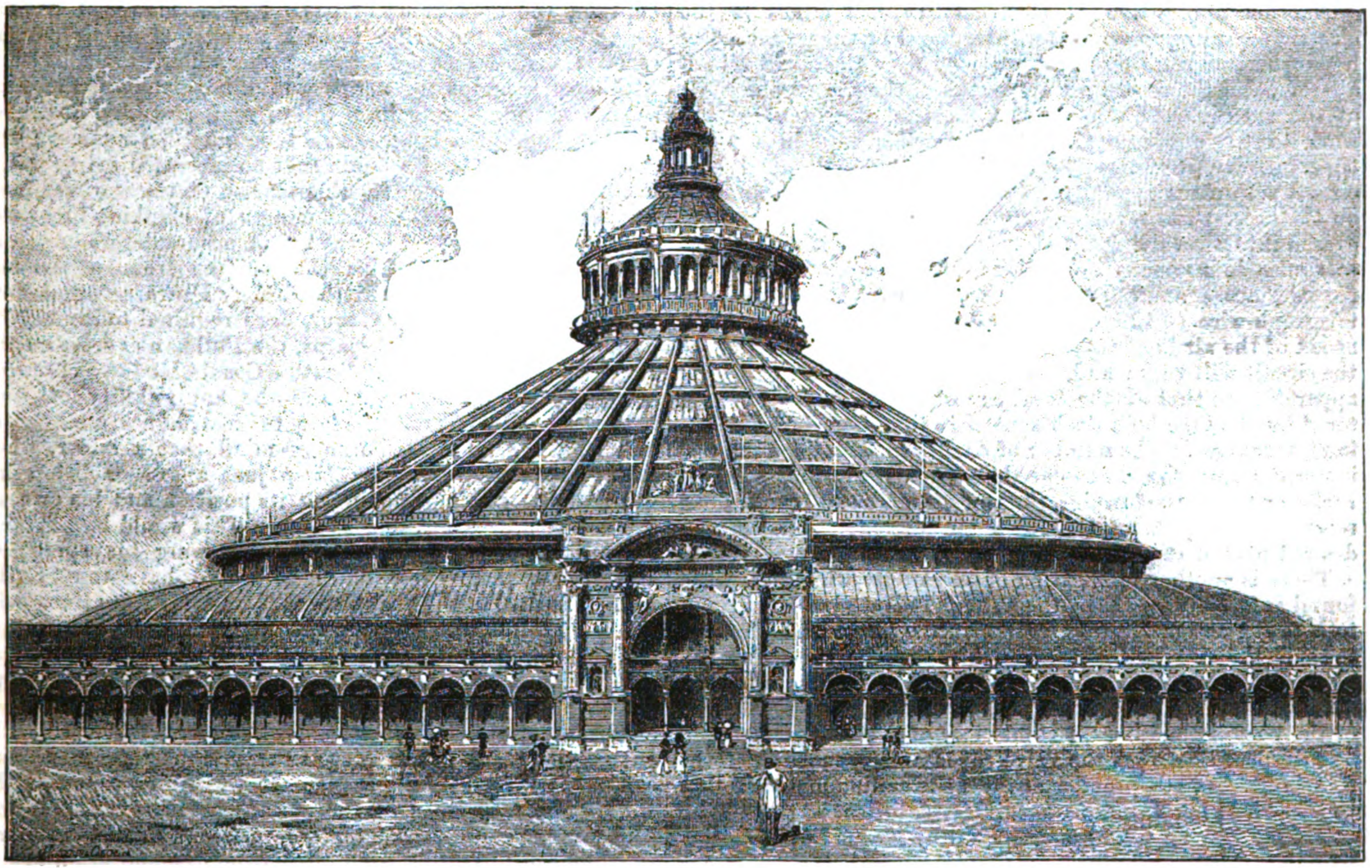
The electrical transmission of special orders is effected by

* A paper read at the late Liege meeting of the Institution of Mechanical Engineers.

the two dial circuits previously mentioned; the current being supplied from the batteries required for the bell service. The transmitters are simply circuit closers, provided with mechanical means for ensuring an electrical contact of given duration; and by means of an air-piston, provision is made that the apparatus cannot be left in such a position that the circuit remains closed. The order transmitted to the receiver is also shown on the dial of the transmitter's instrument, and he only can alter it. The receiver is unable to alter either his own dial or that of the sender. This secures an absolute block system. The receiving instruments are provided with a peculiar check escapement to impel the ratchet-wheel on the passage of the current; and the balanced action of the armature of the receiving electro-magnet locks the indicating needle in the proper position. The same arrangement is applied to the indicating dial of the transmitting instrument. In practice twelve separate orders may be transmitted in ten seconds.

loaded trucks down, contrary to the provisions of the Mines Regulation Act, he will not start his engines. The repetition by the receiver of the sender's order of "men coming up" (or going down, as the case may be) constitutes an absolute block, and informs the engine driver of what he is winding in the up cage; it also prevents mistakes between the banksman and cager, through which many fatal accidents have occurred previous to the introduction of this system. A diagram showed the arrangement of lines and instruments for shaft signals, as in operation at the Risca, Harris's Navigation, and Cannock and Rugeley Collieries.

Provision is further made, if necessary, for electrically interlocking the kips with a semaphore in the engine room; so that when the kips are withdrawn by the banksman, to allow of the free passage of the cage, the arm of the semaphore is moved from "on" to "off" by the action of an electric current automatically transmitted from the banksman's battery at the moment of pulling over the lever. This semaphore thus indicates automatically to the driver in foggy weather the operations of the banksman.



VIENNA EXHIBITION.--THE ROTUNDA.

Latterly, however, in the present year, with a view to leaving the banksman and cager at liberty, it has been found desirable to substitute clockwork transmitters in place of the step-by-step transmitters. In these new instruments the natural operation would be for the clockwork to run itself down. This is prevented by a revolving projecting pin coming in contact with the pin of a lever corresponding to the zero point on the signal, and denoting "safety." On pushing back this No. 0 lever, and pulling out No. 5 lever, the clockwork revolves, makes five separate contacts, transmits five electric currents of given duration, and actuates the receiving apparatus five times; the corresponding order, namely, "men coming up," being simultaneously indicated on all the dials in the circuit. The revolving projecting pin of No. 5 lever then arrests the clockwork until the transmission of the next signal, before which No. 5 lever must be pushed back. The receiving dial in the engine room thus informs the engine driver of what is passing; and if No. 1 cage is drawing men up and No. 2 cage is sending timber or

In engine-plane signals, the bell signals are made at any part of the road, by simply making connection between the line and the return wire, and thus closing the circuit; this can be done by the boy in charge of the journey while the tubs are running. Narrow or dangerous inclines where power is used to work the trains are a fruitful source of accident. Men using the inclines as travelling roads, and thus meeting the tubs coming out, are crushed against the sides of the road. Under certain circumstances the writer has found it advantageous to protect the roads by means of electrical train-indicators. The indicating instruments used at each end of the block section of the road thus protected are constructed as follows:—An electro-magnet, M, is provided with an armature, K, balanced on a pivot, at the end of which is a semaphore arm. The armature and the signal being about equally balanced, when a current flows through the electro-magnet M the armature K is attracted, and the

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semaphore arm flies up to "danger." To show "line clear," or safety, when required, the operator presses down the lever E, which mechanically throws the signal to a position of safety. The keys used for transmitting the current are what are technically called "Morse keys," and are fitted underneath the semaphore signals.

When in use in coal mines the apparatus is thus fitted up:—Supposing A and B represent the two ends of the incline or plane, it will be seen that a man can enter the section at B, the semaphore indicating "line clear;" but when in charge of trucks or tubs he should in doing so throw the signal at A to "danger," and then no one should start from A to B. Where compressed-air locomotives are in use this system is almost essential to the safety of the men if the road is used as a travelling road. Some of the worst accidents the writer has had experience of have originated in using engine planes as travelling roads without proper means of ascertaining whether it is safe to enter; and he submits that no power should be used for haulage underground unless electric signals are used and the planes properly protected.

Another application of electricity in coal mines is the electric recording anemometer introduced by the writer. The hemispherical rotating cups are placed in the main return air-way, and the recording apparatus in the fan engine room at the surface. This apparatus consists of suitable clock-work to pay out a given length of paper tape in a given time. Every five minutes the clock closes a local electric circuit within the apparatus, and thus the time is punched on the tape. The revolving cups in the return air-way are geared into a revolving wheel, so insulated that it makes contact once in so many revolutions. This apparatus and the recorder are connected together with No. 11 galvanised-iron telegraph-wire (0·120in.). According to the variations in speed of the air in the mine, the number of these closings of the circuit will vary; and, by means of a similar punching apparatus to that of the local circuit, each contact is registered on the tape by a dash similar to that of a Morse printing instrument. The number of dashes in each five minutes' interval shows the mean speed of the air, together with its variations, the tape forming thus an automatic and continuous record of the speed of the main air-current, taken at any desired part of the mine.

There is another application of electricity which has been found extremely useful by the writer. It is desirable at times to hear the action of pump-valves in the pit, without having to send the sinkers down. For this purpose the writer has used with success a modified telephone, attaching it to the outside of the valve cover; but to get really exact repetitions of the beat of the valves, a stout piece of asbestos card should be interposed between the valve cover and the mouth of the telephone. A little practice enables the engine-man to follow the action of the valves as accurately as when, in the human body, the heart's action is examined by means of the stethoscope.

II. *Application of Electricity in Mining for Illumination and for Transmission or Storage of Power.*

In 1881 the writer experimented at length on the illumination of the pit-bank and screens at Harris's Navigation Collieries. A Gramme dynamo machine was driven off an engine that worked a Schiele fan, thus ensuring great steadiness of motion and economy in motive power. The result of the experiment showed that incandescent lamps were useless, and powerful arc lamps, fixed 40ft. above the ground, the most suited for the purpose. On account of the absence of colour in the light, the coal trimmers could pick off "brass" and "pyrites" quicker by the arc lamps than by incandescent lights. In every way the experiments proved conclusively that electric illumination of the surface was desirable at a mine of any great magnitude, and that the ordinary engineering staff of a colliery was capable of maintaining the appliances in operation after a week's instruction; but it was generally agreed that the introduction of alternating high-tension current machines was very unadvisable, on account of the likelihood of accident to the men. It was observed by the writer that no amount of warning to the colliers would induce them to leave the line wires alone. Of all types of dynamo machines, the Edison low-tension machine is most suited, in the writer's opinion, for colliery purposes; while the Brockie, Serrin, or Crompton arc lamps are suitable, if an arc is required for illumination, in connection with a Gramme or Siemens dynamo.

At the Risca Collieries the electric light is introduced into the pit from a dynamo machine driven at the surface. The cable is taken down the shaft, and connected with a series of Crompton incandescent lamps of large size at the bottom. These give an excellent light, and facilitate very greatly the work of the cages and the men in the gate-roads. But as regards the introduction of such lights into coal mines, for the purpose of illuminating the working stalls and faces, the writer wishes to draw attention to the 7th general rule, Section 76, Mines Regulation Act, 1872, which provides that "In every working approaching any place where there is likely to be an accumulation of explosive gas, no light or lamp other than a locked safety lamp shall be allowed or used." It must be borne in mind that with safety lamps a constant watch is kept on the appearance of gas. Now, a blower of gas has been known by the writer to back up against an air current of 65,000 cubic feet per minute passing down the split; and with electric lamps no notice would be given of the fact. Such accidents—or again, a fall of roof, breaking a wire, or the breakage of a lamp—cannot be guarded against; and hence the writer is of opinion that no increased safety would be afforded by the electric illumination of the working faces from dynamo machines. The danger of breaking line-wires may indeed be avoided by the use of accumulators or secondary batteries, charged at the surface from a dynamo machine. But it is stated that thirty Faure accumulators, weighing in all about two tons, were required to illuminate, by means of incandescent lamps, the Pullman express on the London, Brighton, and South Coast Railway between Brighton and London. Hence the applicability of such batteries in their present state to coal mines seems very doubtful. It must be borne in mind that a miner, when holing, requires his safety lamp just above or below his work, and is constantly shifting its position and his own, as the holing progresses, to set sprags. This would be a serious difficulty; and further, before withdrawing his sprags to allow the coal to come down, he would have to move the incandescent lamp away altogether and refix it afterwards. Allowing ten minutes for the two operations, this in a mine of sixty working stalls would entail a loss of ten hours per day, say one man's labour, or 3s. 6d. daily. Except in long-wall work, reflected illumination by means of electricity would be impracticable. In effect, therefore, without going into details of cost at the present time, electricity can only be successfully applied to the illumination of the working faces by means of a hermetically sealed glass incandescent lamp, containing a supply of electricity for nine hours' consumption. If this is charged from dynamo machines at the surface, due regard must be had to the length of time occupied in the operation. The weight of each electric lamp should not exceed that of the present lamps in use, or 3lb. as a maximum. Such an appliance does not at present exist.

The useful application of electricity for the transmission of power would be confined to underground haulage, on the electrical tramway principle of Sir William Siemens and others. But, according to the writer's information, such engines as those constructed at the Grange Iron Works, Durham, or compressed-air locomotives, are capable of being used far more economically than electricity; so that the question of electric haulage need not be considered. In support of this statement the writer may state that compressed-air locomotives have been recently introduced into the Cannock and Rugeley Collieries, with a result that may be regarded as eminently satisfactory. The load taken at each journey is 10 tons, the gradient being $1\frac{1}{2}$in. per yard, or 1 in 24. The distance run is 200 yards, the total daily work 300 tons, and the speed 8 miles per hour. The cost for haulage is $\frac{3}{4}$d. per ton. The air is first compressed to a pressure of 75lb. per square inch, and ultimately to a pressure of 350lb. per square inch for use in the locomotive; and by having an excess of receiver-room all difficulties of latent heat are

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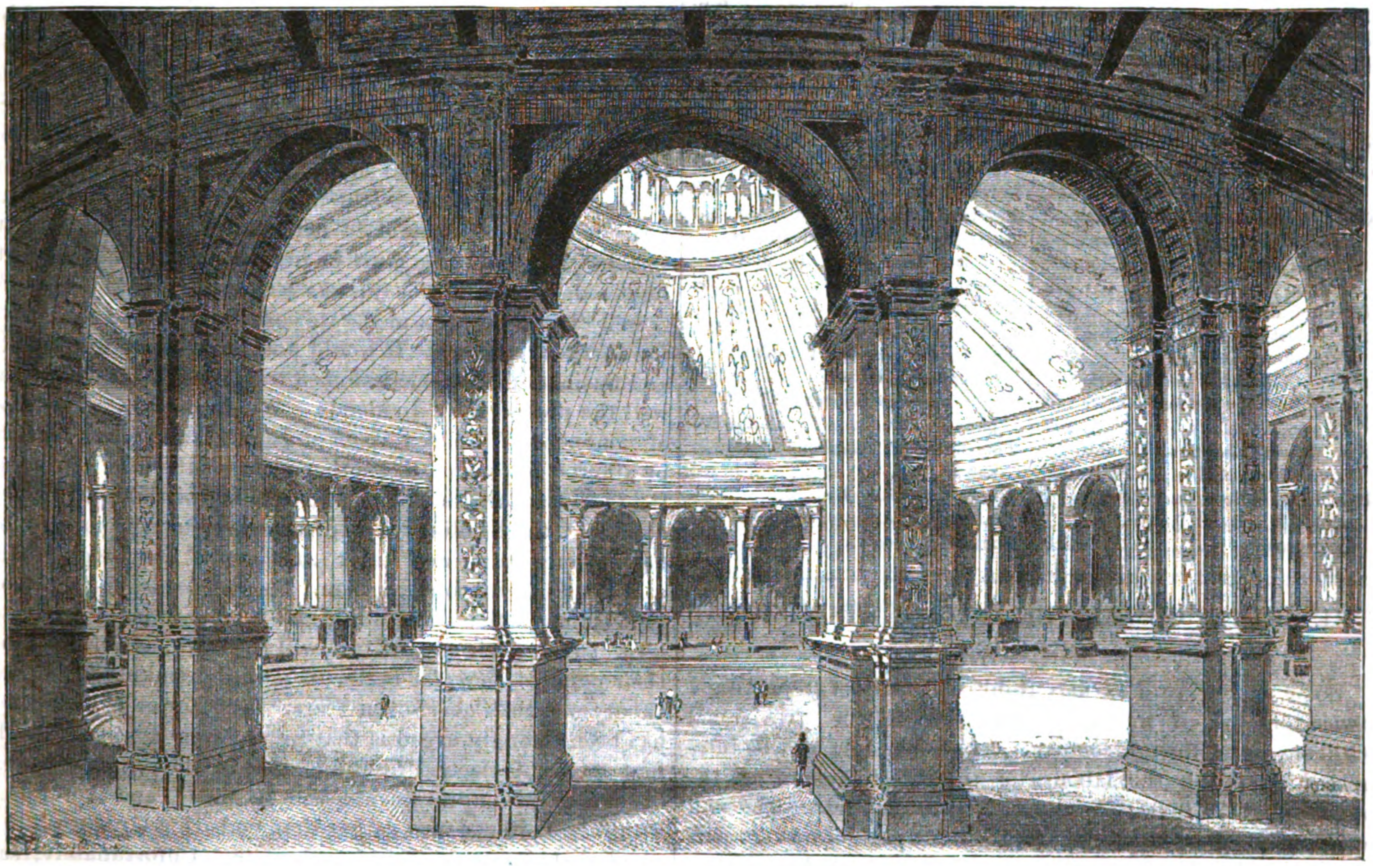
avoided. The cost of the locomotive was £250, and that of the compressor £70; and the engine does the work of three 14-hand horses. The cost of producing an equal amount of power by means of electricity would be more than twice that sum; and the electrical leakage in coal mines would be an almost insurmountable obstacle to its use.

Steam hauling engines and compressed air locomotives, with the tail-rope system in use at many collieries, have proved so satisfactory and economical that the time has not yet arrived when electricity can be economically applied to take their place; whilst the transmission of power to fixed points in coal mines is undoubtedly best secured by means of compressed air, the exhaust of which is of such value for ventilating the workings.

Recapitulating the points mentioned, the writer advocates the use of electricity for the purposes of signalling and illumination, as regards the pit-bank and pit-bottom; but cannot at present approve its adoption for the transmission of power in the workings, or for illumination at the working faces. He is of opinion that no increased safety would be thereby derived, and that inconvenience and danger might arise through falls of roof; whilst the constant watch upon gas, kept by the present extensive use of self-extinguishing lamps, would be removed. Lastly, in the writer's opinion, the 7th general rule of the Mines Regulation Act, 1872, would not be complied with in such cases.

With regard to the use of electricity for signalling, the writer is convinced that the time has arrived when rapid-winding collieries should abandon their old hammer-and-plate system and adopt dials. Experience at the Risca Colliery showed that it was impossible to work a comprehensive system of underground haulage from the surface without electric signals. But it should be borne in mind that, unless electric signals are erected by competent men, they are far more dangerous than ordinary mechanical signals; and that where the electric signals are in use it is desirable to have at least one man instructed in a line-man's duties. This applies equally in the matter of electric-light machinery. The writer has brought the subject before the institution, after several years' experience, because he is impressed with the present inadequate signalling arrangements, and the increasing risks to which all classes of underground men are exposed by the introduction of rapid-winding machinery on engine-planes where mechanical signalling is used. On the other hand, the application of electricity for surface illumination is only a convenience and not a necessity; while for underground illumination the writer adheres to self-extinguishing safety-lamps.



VIENNA EXHIBITION.--INTERIOR OF ROTUNDA.

DEATH OF MR. FLOYD.

We regret to notice the death of Mr. Floyd, the telegraph superintendent of the Great Indian Peninsular Railway, which event took place on the evening of Sunday, the 1st July. Mr. Floyd had been for nearly two years telegraph superintendent of the G. I. P. Railway, and since, says the *Bombay Gazette*, "he came to this country he had by his genial disposition endeared himself to all his friends and brother officers in the service. He was a very talented man in his profession, and since his arrival in India had, we believe, effected great improvement in the working and management of the G. I. P. system of telegraphs. Mr. Floyd was a member of the Society of Telegraph Engineers, and joined the G. I. P. Railway on the recommendation of the highest authorities on telegraphy in England. His experience was very extensive, and amongst other improvements he had patented an invention for communication between passengers, guards, and drivers which is now in use on the local trains, and working, we understand, very efficiently. His loss will not only be felt by the railway company, but by the profession generally."

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THE ELECTRICIAN.

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THE SELECT COMMITTEE AND THE PROVISIONAL ORDERS.

Some of our readers may think us guilty of repeating a twice-told tale if we once again refer to the Provisional Orders; but although comparatively few people may be interested directly in the labours of the Select Committee, the result of their investigations will be widely felt. The evidence given was necessarily, for the most part, of no very particular interest, yet it is evident that a portion of the evidence must be of great interest to all desirous of progress in electric light work, giving as it does the conclusions of those who have had most experience in the work as to cost, prospects, adaptability, &c., of the electric light in its various phases. Thus we have, on the one hand, a most distinguished man of science deciding absolutely against the arc light for domestic purposes, while, on the other hand, we have a company whose system is an arc system with the lamps in series, intimating, if not actually saying, that such a system can be adapted for general lighting. For the moment we may regret that electric light companies should at this stage of the proceedings oppose each other, but it may be that this early opposition will clear the way for better and more extended work in the long run. It may be well to briefly recapitulate the state of affairs. Last Session an Electric Light Act was passed, giving certain authorities to the Board of Trade. Provisional orders and licenses could be granted with the consent of Parliament for lighting specified districts by means of the electric light. There being several companies in the field desirous of lighting special districts, interests have clashed, and a Select Committee was called upon practically to decide between the contending parties. So far as we can gather from a careful examination of the evidence tendered, the opposition centred around three points: (1) Rival companies contending for possession of a district to use different systems, (2) opposition by new companies, so that by retarding the orders they might be put on the same footing as the old companies, and (3) opposition because of the desire to rest and be thankful. As examples we may cite (1) the opposition of the Jablochkoff Company to those of Swan and Edison, (2) that of the Telegraph Construction and Maintenance Company to the Edison, and (3) that of the Westminster Board of Works to any lighting by electricity at all.

Undoubtedly great difficulties arise in deciding between competing companies, and, perhaps, still greater in deciding the question of the status of a new and powerful company desirous of being placed upon the same footing as older companies. Of course those companies who have applied for the first provisional orders have applied for orders for the districts they deem most suited for obtaining a good business, and it is therefore the interest of the newer companies to defer if possible any decision. Then, of course, there is the bugbear "monopoly," which term is used to intimidate nervous people. It is quite certain that some one must be first, and must be allowed to light a district, and it is just as certain that if the lighting is well carried out at a moderate cost there will be no room for another company. It would not, in fact, pay to compete, and business men are accustomed to look ahead and consider well the prospects of dividends. We discussed the question of "monopoly" in our issue of June 21, and may therefore be allowed to pass on to another phase of the tale. Many of the local authorities and a large number of thoughtful men object to the handing of a district over to a company for twenty-one years, and their arguments are weighty and worthy of careful consideration. The companies for the most part maintain that they would be unable to make a shorter term pay. Their expenditure will be heavy, and it is, from their point of view, far better to spread a sinking fund over twenty-one than over seven years. Another objection which has been strongly urged is that we are even now only in the first stages of electric lighting—that in the course of a year or two great improvements will be made, and therefore it would be better to wait rather than embark a large capital in plant that may soon become obsolete. Unfortunately, this argument is always available, and would be as good a few years hence as now. If we wait for perfection we shall never commence work.

The question that has been well debated before the Select Committee, and has been closely scrutinised from various standpoints, is that the maximum cost to be charged per unit of electrical energy supplied. The price allowed by the Select Committee in the Swan and Edison orders passed is 8d. per unit, which is equivalent to gas at 6s. 8d. per 1,000 cubic feet. The opponents of these orders maintain that this maximum is too high, and that other companies are prepared to supply at a maximum price of 6d., equivalent to 5s. per 1,000 cubic feet of gas. They also hold that the saying of Artemus Ward as to there being a "good deal of human natur in man" is very true, and that if the companies are allowed to charge a maximum, the price charged will approximate towards this maximum. On the other hand, the companies desirous of obtaining the orders say they only ask such a maximum as

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a precautionary measure. They may find that few units are sold, and hence the charge must be high, but they hope that the demand will be large enough to ensure a price much below the maximum; indeed, they intimate their intention of commencing with a lower charge in order to induce a large sale. There is no doubt that the companies will fix as high a price as they think can be charged with safety, and which will not deter the public from purchasing.

An objection to the provisional orders as proposed was made by Mr. Jeune before the committee. It was pointed out that the orders deal with two areas, A and B. The area A, which forms the best part of the district from the seller's point of view, will be lighted at once. If the experiment succeeds the undertaker will probably extend the lighting over area B, but if the success is doubtful the local authorities will have to get the latter area lighted as best they can. No doubt there is a good deal of truth in all these objections, but we are mistaken if any method of procedure can be suggested that will be altogether satisfactory. Are we to wait till every one is satisfied before commencing work, or shall we not rather hasten forward some of these experiments on a practical scale, looking to time and experience to bring improvements, just as time and experience have improved our locomotives and steam engines? The Select Committee were evidently in favour of commencing work, for they with a few minor alterations passed the orders brought before them for consideration, and we hope we may very soon have to record the commencement of the works necessary to carry the orders into effect. Of course the Bills may not pass through Parliament, though this, we think, is improbable, after the attention that has been bestowed upon the question by the Board of Trade and the Select Committee.

SELECT COMMITTEE ON ELECTRIC LIGHTING PROVISIONAL ORDER BILLS.

The first witness before the committee was Mr. T. E. Farrar, C.B., who was examined to give evidence as to the principle upon which the Board of Trade had granted these orders. These principles are very clearly set forth in the description of the practical effect of the Act of last Session. Mr. Farrar said: The Act of last Session, which was very carefully considered by a Select Committee, took away no existing powers—that is to say, all persons can supply electricity just as they could have done if that Act had not passed. It then conferred certain powers. First of all, it conferred powers upon the promoters of these undertakings to break up the streets; and, secondly, it conferred powers on local authorities to spend the money of the ratepayers and to borrow for the purpose of these undertakings. Those, practically speaking, are the two powers which were conferred by the Act of last Session. Then those powers were to be obtained in two different ways. First of all, those powers might be obtained by a license, which could be granted by the local authority with the approval of the Board of Trade; or, I should rather say, by the Board of Trade with the consent of the local authority. Powers granted under such a license as that would last for seven years only, and, consequently, would probably in most cases not be sufficient to tempt capital in a new undertaking. The second mode in which the powers might be obtained was by a provisional order. That provisional order could be granted by the Board of Trade, with or without the consent of the local authority, after hearing the local authority. In the case of provisional orders, no limit of time was imposed; the powers under a provisional order might last indefinitely, subject to the conditions I am going to mention. Now, it is important in the first instance to state what was the reason for giving this power to grant provisional orders over the heads of the local authorities. It was felt that whilst local authorities represented the ratepayers, they were in many cases inert bodies not willing to adopt new things, in some cases, perhaps, prejudiced by being the owners of gas undertakings, and therefore not by any means certain in all cases to give the ratepayers the benefit of this new invention. Whilst, therefore, they were empowered to obtain the provisional order themselves, power was given to the Board of Trade to grant a provisional order over their heads after consulting them. It is unnecessary for me to enlarge upon the questions of private capital *versus* public bodies. I think all experience in this country shows that, whilst capital is extremely active, and will always support a new invention if there is a prospect of success, there is no such active motive power upon the part of governing bodies. They take up a thing when it is done, but they are not persons who generally are willing, or, perhaps, are the best persons to take up a new invention. Then the Board of Trade were bound in granting these provisional orders to insert conditions as to the limits within which the powers were to be exercised. As to the performance of the duty of supply, the safety of the public, the price to be charged for inspection, penalties for non-performance of their duties by the undertakers, and as to the revocation of the order in certain cases, various clauses were introduced for the protection of the undertaking; a special clause was introduced for the purpose of securing safety, and, with regard to that, the Board of Trade were enabled, in spite of anything which might be contained in the provisional order, to make from time to time such regulations as they might think necessary for the purpose of safety. Provision was made for keeping careful accounts; the use of electricity was to be free when it had once been supplied by the promoters, that is to say, when a person had once got the electricity into his house he might use whatever lamp or form of apparatus he chose. Clauses were introduced to guard against undue preference, and, lastly, and the most important condition of all, a condition was inserted for the purpose of preventing the evils which have arisen from monopoly in gas and other matters. And Clause 27 of the Act of last Session was introduced, enabling the local authority to buy up the undertaking of the company at the end of twenty-one years, on condition of paying the full price of the undertaking as the plant of a going concern. That is a provision similar to one which was introduced into the Tramway Act, and under which all tramway undertakings are at present carried on. Then I think it may be observed that at present, at any rate, it seems extremely doubtful whether any monopoly can ever be obtained in the case of gas and water. It is very well known that in the case of gas the monopoly is obtained by the use of the streets. There is no such thing as a legal monopoly of gas; but it has been found so inconvenient to break up the streets that it was found necessary to give one company the command of a town, and in London to district the metropolis amongst different companies.

Mr. Farrer in answering questions relating to price thought that at present competition with gas, and in the future competition with electricity, would be sure to keep down the price of the electric light, and extracts were quoted from the report submitted to Parliament, and it was stated that preference had been given to the applications of local authorities, though it might not be the opinion of the Board that the present was a time for such authorities to undertake so novel a thing, and that in the case of companies means had been taken to settle the schemes in accordance with the wishes of the local authority. "One hundred and six applications were received on or before the 21st December, the date prescribed by the rules; 23 of these were promoted by local authorities, and 83 by companies. Ninety-seven of the applications related to places in England and Wales, eight to places in Scotland, and one to Belfast, Ireland. Thirty-five related to London and the suburbs. A list of the applications will be found in the appendix to the report. Many applications were made to the Board of Trade for a model order, but this they were unable to furnish until they had

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some experience of the provisions suggested by promoters, and of the objections of local authorities and others interested. Eventually, after a consideration of the orders as deposited, and of the objections which had been lodged against them, the Board of Trade determined upon the principles upon which the applications should be dealt with, and on the 28th February they circulated model clauses for adoption, with such modifications as might appear to be necessary. Prefixed to these clauses was a memorandum, of which a copy will be found in the appendix. From this it will be seen that the leading principles upon which the Board of Trade were prepared to grant provisional orders, and to which, speaking generally, they have adhered, are as follow:—(1) That the undertakers should be compelled to light some portion of the area selected within a given time; other portions to be supplied on requisition. What these areas should be in each case was a question which the Board of Trade desired to leave to be settled between the local authority and the promoters, "and which I may now mention has been so settled in almost all cases." In most cases the areas allotted were divided into a compulsory area described in Schedule A, and a further area described in Schedule B. In area A certain works were to be at once commenced, and the rest of that area was to be lighted on requisition. As to area B, the promoters were to be able, at any time after the commencement of the order, to apply to the Board of Trade to direct that any part or parts of that area should be added to the area of supply, and at any time after the expiration of two years from the commencement of the order, the local authority were to be able to call upon the promoters to undertake to light any part of it, with power to the Board of Trade in case of default to withdraw that part from the operation of the order.

We may state here that in his subsequent evidence Mr. Farrer said out of 106 applications 47 had been rejected or withdrawn, and 59 had been embodied in 69 provisional orders, some of the original applications being divided for convenience.

The action taken by the Board relating to capital, profits, revision of prices, monopoly, &c., was explained almost in the words of the published reports. It was strongly insisted that the Act gave no monopoly. An explanation was given with respect to the areas mentioned in the orders—an area, for example, to be compulsorily lighted within a given time, and so on—also as to the method of supply and measurement. It was pointed out that a provisional order may be revoked, or transferred to the local authority.

With regard to the Duke of Westminster's opposition, it was indicated that an agreement was in a fair way of being settled. It seems that there were originally three competing companies in the Strand district—Edison, Brush, and Swan. Brush did not oppose, and the Edison and Swan Companies arranged matters, when there stepped in the Jablochkoff Company—more particularly in opposition to the Swan Company, or rather as "content to do the lighting of a large part of the district under a license for seven years." The eastern district was given to the Swan Company, "with the condition that if within a certain period the Strand District Board of Works themselves, or the Jablochkoff Company with their consent, obtained a license for that part of the district, the power of the Swan Company should cease altogether." With regard to Edison and Swan, "it is a question of convenient arrangement." The application of the Jablochkoff Company has not yet been considered, but it involves the question whether a company which has not yet attempted parallel lighting obtaining the license would not come in the course of a few years and acknowledge their inability to do the work completely unless the license were prolonged to twenty-one years.

With regard to the opposition of the Westminster Board of Works to the South Kensington and Victoria orders, it amounted to a simple "*Non volumus non possumus*, we object to all orders."

Mr. Farrer handed in a paper containing the memorandum of the Board of Trade relating to provisional orders, prepared by Mr. Meysey Thompson.

Mr. Pope, who with Mr. Moulton appeared for the Swan and Edison Companies, pointed out that an electric lighting district should be compact, that the Jablochkoff system was essentially one adapted only to street lighting, and that it was not to be expected that the company could raise capital and undertake an entire change of system, such as would be necessary if they undertook domestic lighting, for an interest limited to seven years, and it was argued that it would be little short of disaster to hand over the district to a company with no experience except in street lighting, and with a system adapted only to that class of lighting. The opposition entered to the price involved a question they were not exceedingly anxious about "so long as Parliament will give us such a maximum as is prudentially required to provide against the contingency of a delay in the acceptance of the electric light." Undue price could be controlled by the authority vested in the Board of Trade. Mr. Pope argued that the Strand Board supported the Jablochkoff Company under a misapprehension, and when giving their support had solely in view the question of street lighting.

The examination by Mr. Bidder, for the Telegraph Construction and Maintenance Company, of Mr. Farrer, when recalled, dwelt mainly upon the price (9d.) mentioned in the Edison scheme for the St. James district, the argument being that no district, and certainly not the best, or almost the best, district, should be handed over to a company charging 9d., when another company would give the light at 6d.

The evidence of Dr. J. Hopkinson was to the effect that the undertakers would be under an obligation to keep a constant uniform pressure upon the electric mains, day and night, varying not more than 5 per cent. either way, and that a large part of the aggregate cost would be almost the same whether the number of units of electricity supplied were few or many. The Edison Company hoped to charge much less than the maximum price (9d.) but that depended, of course, upon the number of units of electricity sold. The witness believed the Edison dynamos to be as efficient as any, and they gave a continuous current as required for incandescent lighting under these orders. He preferred a continuous current to an alternate, because the former can even now be used to transport power, or to deposit metals, whereas the latter is not as yet adapted for either of these purposes. The Edison Company had had great experience not only in England, but in America, and in other parts of the world. Taking the particular case of capital, £80,000, annual consumption 360,000 units, the cost, allowing a profit of 10 per cent., would be 15·4d. per unit. Doubling the consumption, viz., 720,000 units, other conditions the same, the price estimated was 8·22d. per unit. As business men, no doubt an effort would be made to get a larger consumption at a low rate. The Jablochkoff system was not worked on the parallel arc system, nor at the potential required by the order, nor could the light be lowered satisfactorily, nor lighted without a special attendant if it went out.

At a later stage Dr. Hopkinson stated that "the series system" was, in his opinion, "wholly inapplicable to the purposes of domestic lighting," that he doubted if the arc light was preferable even for street lighting, but the arc light was cheaper.

Sir Frederick J. Bramwell in his evidence stated that there was no uncertainty with regard to the cost of producing electricity under given circumstances. He said that the convenient formula might be correct—that multiplying the electric unit by ten the result gives the price per illuminating power equal to 1,000ft. of gas—thus 9d. per unit is equivalent to gas at 7s. 6d. per 1,000. He believed that for a time the price of gas and electric light will be widely marked.

Mr. Crompton in his evidence was emphatic against the possibility of profitably carrying out the scheme upon a seven years' license, because charges would have to be divided over seven instead of twenty-one, and greatly increase the cost.

Sir Daniel Gooch, M.P., gave evidence to the effect that owing to the Articles of Association of the Telegraph Construction and Maintenance Company not covering the supply of electricity, that company had to wait for an Act of Parlia-

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ment before such supply could be undertaken. The Act had been obtained, and now the company is in a position to supply. Sir George Henry Richards, F.R.S., the managing director of the company, stated that they were desirous of carrying out at once an installation of 10,000 or 15,000 lights in St. James's. Inquiries had been made, and the first approximate estimate of the total number of lights to be provided for in the district comprised in Edison's Schedule A is 120,000, involving a capital expenditure of not less than £400,000. The maximum charge this company proposed was 3s. for electricity equivalent to 1,000 cubic feet of gas, as against 4s. proposed by the Edison Company.

Mr. J. E. H. Gordon stated that the area covered by Edison's Schedule A was about 203 acres, and corroborated the above estimate as to lights required and cost. The Telegraph Construction and Maintenance Company proposed to put into their Schedule A about 100 acres, and the cost of this to entirely supersede gas would be about £200,000; taking, however, only the principal streets and houses through the best portion of the district the cost would be about £100,000. They proposed to use the Gordon dynamo, and by using this could supply electricity cheaper, while the dynamo could be adjusted to give any E.M.F. that would suit the best lamp. Mr. Gordon was emphatic that the use of his system would tend to cheapness. With regard to the possibility of the breakage of a main, Mr. Gordon said "I have 128 wires from each of my dynamos to go to the two supplying mains, so that if any one of my 128 wires breaks, it only cuts off a corresponding fraction—that is to say, 1-128ths of the current." The witness also mentioned that the question of the Nottingham lighting had been postponed till next year to see what other towns did. In the case of an installation of 27,000 lamps, "the mains would be considerably less than a quarter the whole cost." Public lamps are more valuable and paying, lamp for lamp, than private lamps, as they burn more hours in the year. The public lamps burn, say, 4,180 hours in the year, while the private lamps burn a much fewer number of hours.

Mr. C. E. Spagnoletti and Sir C. Bright testified that they believed the Gordon system to be very good.

Mr. Crompton, on being recalled, stated that the Swan Company was prepared to deposit £12,000 upon Schedule A, and were provided with funds to carry out the compulsory work and the first demands from the extended district.

Captain J. Wilson Johns stated that he preferred the Mutual to the Swan Company, and believed that the Mutual could supply at a cheaper rate than the Swan, not being burdened with a large capital upon which a large return would be expected.

Other witnesses were called, who stated their intention of supporting the Mutual Company when formed.

Ultimately, after the committee had privately considered the evidence, the chairman stated that the committee had agreed to pass the Edison order subject to the following alterations :—

1. That the Edison order should be extended so as to cover the whole of the parish of St. Martin's, and to include the whole of St. Paul's, Covent Garden.

2. The Edison Company only to be permitted to be in the eastern Strand district for the purpose of generating electricity, and constructing and carrying on their works.

3. The maximum price for the Edison provisional order to be equivalent only to that of the Swan Company, viz., 8d. per additional unit.

4. The proviso corresponding to Clause 67 in the Swan order to be struck out.

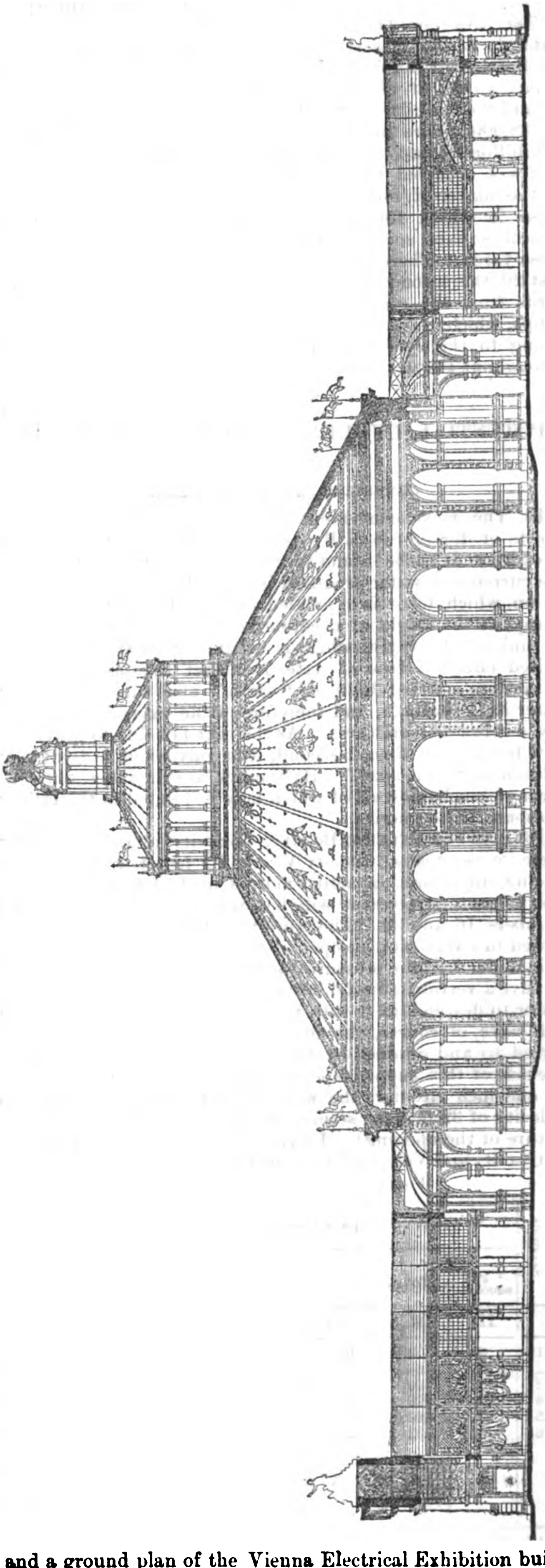
That the Swan (Strand) order would be passed subject to corresponding alterations, Clause 67 being struck out.

At a later period of the day, Bill No. 5 having been amended, was read, and agreed to, and the chairman was directed to report it, as amended, to the House.

The committee concluded its labours on Tuesday, and passed the Swan (Kensington) order, striking out that part of the area, however, under the authority of the Westminster Board of Works.

THE VIENNA ELECTRICAL EXHIBITION.

We publish this week a front view, a longitudinal section



VIENNA EXHIBITION.—LONGITUDINAL SECTION.

and a ground plan of the Vienna Electrical Exhibition buildings, also a perspective view of the interior of the Rotunda.

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The total area covered by these buildings is 46,000 square yards, of which there will be at the disposal of exhibitors a total of 38,000 square yards, apportioned as follows: Rotunda 14,000, transcepts and galleries 12,500, open yard space 11,500. As regards area the coming electrical exhibition will certainly be the largest yet held. In the exhibition held in the Palais de l'Industrie, Paris, the area covered was 38,000 square yards, of which, however, only 23,500 were on the ground floor, whilst in the Vienna Exhibition the whole of the 38,000 square yards are on the ground floor. The Munich Exhibition covered only 12,000 square yards, and an equal area was occupied by the Crystal Palace Exhibition. Also in the matter of loftiness the buildings in the Prater excel those in which former exhibitions were held. The total cubical square enclosed by the Rotunda is half a million cubic yards. There are three internal circular galleries, the first 26, the second 52, and the third, the lantern-gallery, 72 yards from the ground level. These will be lit up by arc lamps, which, on account of their great height, will not be trying to the eye, though they will shed a flood of light throughout the vast building.

POTENTIAL, CURRENT, AND RESISTANCE.—II.

BY JOHN T. SPRAGUE.

CONTINUED FROM PAGE 224.

15. The most convenient illustration of the mechanical effects of force, especially as connected with the study of electricity, is to be found in "hydraulics," that is to say, in the currents of water produced in pipes by the force of gravitation, which force is expressed as "head of water;" that is to say, as the height of a column of water, supposed to have an unlimited supply, which is capable of producing the required effects. Head of water is in fact the product of the attractions exerted between "earth" and each particle of water in the column, and therefore of the mass contained in, say, a column of unit area. As the unit fall due to gravity is 16·1 feet in unit time, 1 second, it is convenient to treat that column as "unit head." Hydraulics are, however, only one form of mechanics, all of which may be related to the fall, or motions due to gravity.

16. Laws of Falling Bodies.—Gravity, as an accelerating force, generates a velocity V of 32·2 feet per second, producing, therefore, an actual motion of 16·1 feet per second. For present purposes it will be convenient to use the round numbers 16 and 32. The true "head of water" is not obtained in a vertical pipe open at the bottom, as the column is only under half the pressure due to the height; it is necessary to have a vertical supply so large in section as to allow the water to descend in it with very small "velocity," though it will have, of course, the full "momentum," which is transferred to and retained by the water actually issuing. If in the side of this supply pipe or reservoir we have an opening of one inch circular, the water would issue from it with a velocity of 32 feet per second (ignoring any effects due to the nature of the opening). I have arranged the table of "Force of Gravity and Velocity," to show the effects of such a column.

Force of Gravity and Velocity.

Time in Seconds.	Velocity.		Space Traversed.	Energy.		VI. ÷ 16 gives ratio to unit head.	√VII. which is √Head in units.
	+ per second.	Total.	Acquired.	Per second.	Total.		
I.	II.	III.	IV.	V.	VI.	VII.	VIII.
1	32	32	16	16	16	1	1
2	32	64	32 + 16	48	64	4	2
3	32	96	64 + 16	80	144	9	3
4	32	128	96 + 16	112	256	16	4
5	32	160	128 + 16	144	400	25	5
6	32	192	160 + 16	176	576	36	6
		Momentum V × mass	Energy $\frac{V^2 \times \text{mass}}{2}$		Head of Water. Foot-pounds.	Square of time.	Mec-mot. Force. *M*.

17. The meaning of this table is as follows:—

(*a*) *Force*, when reduced to units, means one second's action, therefore the units of force exerted are *as the times* in seconds, Col. I.

(*b*) The unit force here is one generating a velocity of 32ft., therefore we have, Col. I., times or units of force, each separately shown, Col. II., and accumulated in Col. III.

(*c*) *Momentum* is velocity × mass. Taking 1lb. as unit mass, Col. III. gives us momentum, or quantity of motion acquired.

(*d*) *Energy* is (1) mass × space fallen, so we have the increment per second 16, added to the acquired velocity in Col. IV., showing the gain per second, Col. V., and giving the total, Col. VI.

(*e*) *Energy* is (2) mass × half the square of the velocity. This is often expressed as $V^2 \times \frac{1}{2}$ mass, but, while correct in arithmetical result, this is a misleading statement. Half mass can have nothing to do with the result, which is due to the fact that unit energy 16 is only half of unit velocity 32.

(*f*) Hence energy is as the square of the time, $6^6 = 36 \times 16 = 576$, as shown Col. VII. × 16. Now as the time = units of force (*a*), we have the evidence that the mathematical expression of force is based upon the square root of the corresponding energy. This is an inevitable result of the equality of cause and effect, although the statement may be heretical in form, because it expresses a truth, as do many heresies, in a different form from the dogmas of the orthodox.

(*g*) But *head of water* is as the "height of the column," which is also the "space fallen." Col. VI. therefore gives us "head of water" corresponding to the spaces dealt with, and dividing this by 16, the unit head or space in feet, it gives us the various corresponding data expressed in "units" in Col. VII.

(*h*) Assuming that the area of the column is such that one foot in height = 1lb. in weight, or, generally, that 1lb. mass is falling through the height, Col. VI. gives uy by (*d*) the energy, either *kinetic* or *potential*. See §§ 12 and (*o*).

(*i*) As Col. VI. is the weight of such a column (*h*), it gives us the force defined by the static pressure exerted § 12, but it shows us that this, which I have called the "abstract force," is something different from the "force" expressed in units.

(*k*) The fundamental law of hydraulics, that is of "current" in the case of water, is that *the velocities* (that is currents) *are always as the square root of the heads.* Col. VII. gives us the "heads" expressed as units of 16 feet, therefore the square roots of these give us, in Col. VIII., the relative velocity-generating power of the several heads, corresponding to successive times in seconds, or number of units of force (*a*).

(*l*) This *square root of head*, Col. VIII., is then the same thing as the number of units of force acting, Col. I., and concentrated on the one action or mass. But it does not correspond to the static pressures of Col. VI. and VII.

(*m*) But it is evident that the two definitions of "force," § 12, must correspond. It is impossible that the mathematical formulæ, however much they may disguise the physical causes, should incorrectly represent the facts. According to the system of dimensions, attraction,

or force at a point, is $\frac{L}{T^2}$, Force is $\frac{ML}{T^2}$,

Acceleration is also $\frac{L}{T^2}$, Energy is $\frac{ML^2}{T^2}$,

Velocity is $\frac{L}{T}$, Momentum is $\frac{ML}{T}$.

That is to say, the introduction of *mass* M converts the abstract ideas or powers, acceleration and attraction, into the the concrete idea of a quantity of force, and velocity into momentum, while energy or *vis viva* is the square of the space in which force is expended, which comes to precisely the same thing as the statement in (*f*) above.

(*n*) When a current of water is being actually produced, that is while the attraction of the earth is converted into dynamic force, *the pressure in the pipe would not be that shown Cols. VI. and VII.*, but would be lowered to correspond with the definitions in (*m*).

(*o*) Therefore the vertical pressure of the head of water,

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though it is the abstract force (i), is not the mathematical unit force. It gives us the *potential energy* corresponding to this force, if we consider the area of the column to be such as makes 1 foot in height weigh 1lb. Thus we have the potential energy in foot-pounds in Col. VI., and in units of 16 foot-pounds in Col. VII.

(p) What, then, is this *force* which = momentum-generating power and also = $\sqrt{\text{head}}$, and therefore of necessity = $\sqrt{\text{potential energy}}$? It is the thing described as *Mechanico-Motive Force* (§ 11), and therefore we may symbolise it by M in italics, to prevent the reader from confusing it with M as used for mass in the dimension formulæ.

18. But mechanico-motive force M is the analogue of electromotive force E, and so also current in electricity is the analogue of momentum in mechanics, for unit quantity, as the coulomb, replaces unit mass, or the pound in momentum, and a current of electricity means so many coulombs per second, just as a current of water means so many pounds of water per second. Now, E.M.F. is the dynamic equivalent of potential, and potential (from the present point of view as M, Col. VIII.) is the square root of Col. VII., head in units. It is the square root of the potential energy, and here we may find the explanation of the conflicting definitions and ideas about "potential." The favourite mathematical definition is that "potential is the work spent upon a unit of electricity in bringing it from an infinite distance," which definition makes it as *the potential energy*, not as its square root. On the other hand Professor Baynes told us in the discussion referred to at the commencement of these papers, Vol. II., p. 230, that "the dimensions of electrostatic potential are those of square root of force," and my table above shows that, from the present point of view, M is the square root both of the static pressure before action, and of the potential energy.

19. There is in fact another way of regarding this matter, which will be dealt with in my next paper, in which *electric potential* will be found to express the *potential energy*, and *not its square root.* It is a curious consequence of the construction of Ohm's formulæ that the fundamental elements E C and R may be considered as related to energy either directly or as its square root, and *that both ways will be correct*; apparently inconsistent, they are yet each true and useful. This is really the cause of a good deal of misconception and difficulty, and is never explained, though we may find here the reason that the symbol R in these formulæ does correctly represent both the reciprocal of conductivity, which is as C, and the work expended, which is as C^2.

20. From the point of view at present occupied, then, potential (as including both mechanico-motive force and electromotive force) represents the number of units of the artificial force of the mathematician—force expressed as a quantity—concentrated upon the act of generating a given momentum, *in unit mass*, or, what is the same thing, a given velocity in a defined or unit quantity. Col. VIII. of the table shows this, as the figures are the same as the "times," Col. I., which are as the units (or numbers of actions) of "force" which have been accumulated on the unit "mass" passing through the spaces of Col. VI. and VII.

21. *Current*, therefore, is in water as M and in electricity as E, and these we may call "potential." Now, it is evident that if a given current of water flows through a pipe of 1in. sectional area, an equal current will flow through a second and a third such pipe, and that it makes no difference whether we use such separate pipes or unite their capacities in one pipe of two or three times the capacity. But pipes have another property besides allowing water to pass through them. They offer a resistance, a friction which absorbs energy and converts it into heat. Electric conductors have precisely the same properties, but with a difference as to the way in which energy is absorbed. In pipes this is twofold. 1. Skin, or surface friction, dependent on the nature of the pipe, varying of course *as the surface*, that is to say, as the diameter or *square root of the sectional area.* 2. Viscosity of the water itself, which necessarily varies *as the area* or mass of liquid. In electric conductors there is only a friction analogous to this latter, due to the molecular motions which constitute the current. In each case also the absorbed energy increases *as the length*, and as the *square of the current.* These are the general laws of electric resistance, which it is unnecessary to enter upon here. For present purposes it is sufficient to say that the difficulty may be got over by considering conductors, not as a whole, not as a pipe or wire of such a diameter or area, but as consisting of so many parallel unit conductors or pipes, in each of which similar actions occur, and having a unit length. In this manner we can conceive a conductor of unit *area* or section and length absorbing unit energy while unit current is passing.

This gives us a conductor of *unit capacity*, offering *unit resistance* to unit current, which is, in fact, the best definition of the Ohm unit.

It is obvious that the laws of transmission must be:—1, *Current* is as *capacity*; that is to say, *directly as area*, which is as d^2, the square of diameter. 2, Current is *inversely as* resistance. 3, Resistance (true) is as length and as the *square of the current*, or, which is the same thing otherwise arrived at, as the square of M or E (the potential).

22. The result is that current is *as* force (potential) M or E, and *as* conductive capacity, which we may symbolise as A, giving us C = M, or E × A. This is the natural truth which is disguised under Ohm's formula, C = E ÷ R. Why divide instead of multiply? *In arithmetic it is indifferent whether we multiply by a figure or divide by its reciprocal.* If we, therefore, for the moment, consider R as meaning the reciprocal of A (that is 1 ÷ A), it is obvious that E × A and E ÷ R are precisely the same thing. But using the reciprocal and the division process has this advantage. We have an inverse value to employ, the true resistance, the work done in the conductor, and this is a value which the system of units expresses in the unit ohm, as the work expended in the unit conductor by unit current, which, therefore, being itself an inverse value, is directly expressed by the reciprocal of the conducting capacity.

23. Therefore the symbol R conveys two distinct things:—1. The arithmetical artifice of the reciprocal of capacity; and 2, the work expended by unit current; and these two are summed up in the term "resistance" as used by electricians. The result is that while the actual work, the true resistance, does increase as the *square of the current*, the formula works it out truly by the direct number, because the current itself increases as E. This embodies energy as the square of E, § 17 (f) and (p); therefore we have both cause and effect expressed by the square root of the energy related to them.

24. Here, then, we have the explanation of the common statement that electric resistance is equal for all currents, that is to say, an ohm is 1 ohm resistance for 1 ampere or 20. This, the first statement quoted, § 3, applies to the arithmetical value, the reciprocal; *for a unit conductor, pipe or wire, has the same capacity for all currents*; that is, it will permit 1 unit current to pass under 1 unit force or 20 under 20 units, § 21. But none the less it will, *for both water and electricity*, retain, in Mr. Siemens's words, "a certain amount of energy proportional to that transmitted;" and that is, *for electricity exactly as for water*, in the ratio of the "square of the velocity of flow." I have dwelt so fully on this subject because I have found that it is a great difficulty to most people, and because all electrical books dwell upon the artificial formulæ, and never explain the natural truth which underlies them, and which in consequence they replace.

25. Hydraulic Analogy of Current.—As stated, § 21, it is difficult to present water pipes so as to perfectly correspond with electric wires. It is also impossible to work out water currents by a formula corresponding to Ohm's, when treating them as derived from head of water, or as familiar to us in the network of water supply pipes. In this case the water itself runs away, but the electricity does not, and carries energy with it, while with electricity the energy is wholly *in the circuit.* Consequently in waterworks the force has to have two expressions, one for the work done in the pipes, and the other for the issuing velocity, which has no analogue in electricity. But there exists a much closer analogy in the case of a hydraulic system for doing work, such as actuating the cranes in a dockyard. Here we have a closed circuit in which

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the water circulates, closely resembling the electric circuit, in which the engine and pump correspond to a galvanic battery. Even here the conditions of resistance or friction are not quite analogous, but the relations of force and current are identical. The same "quantity" passes at every section, large or small. The same current can be made to transmit very different energies and do very different work, and that according to the pressure, whether in lbs., per inch, or in volts. Nor has electricity any of the advantage claimed for it over water in transmitting energy in consequence of any difference in the principles in operation.

26. Electricity becomes more economical as the potential is increased, so does water. The limit with electricity depends upon the difficulty of insulation, and the danger of high tensions. It is exactly the same with water, for the strength of the pipes and the danger of bursting them are the exact counterparts of the insulation difficulties. The real advantage is a practical one; the limit of safety has a far greater range with electricity, and its generators and conductors are more simple and manageable than hydraulic machinery and pipes, and are not exposed to risk of freezing, against which however, may be set the danger of overheating the conductors

PRACTICAL NOTES ON INTERIOR ELECTRIC LIGHTING.*

I must, at the outset, dispel any expectation, which the title of my paper may have raised, that a scientific inquiry or dissertation will be submitted. The only plea which I advance is that I will endeavour to confine my remarks to facts and figures, the results of actual experience.

When our esteemed president invited me to prepare a paper for this meeting I was, I must confess, completely at a loss, as I had nothing of any interest at hand connected with our industry which I could present. But, being reluctant to decline, I made some inquiry at one or two of our local manufacturing firms who had been experimenting with the electric light, with the view of eliciting something of interest, as I am strongly of opinion that our attention, as gas managers, should not be exclusively given to our own sphere of everyday routine, but, like a wary general, occasionally reconnoitre the position of "our friend the enemy." I was the more disposed to pursue inquiries in this direction from hearing various conflicting rumours of the result of experience in electric lighting in our place, and more particularly because I had felt a pinch by some diminution in the sale of our gas. I am pleased to be able to say that my inquiries were most cordially met by the gentleman at the head of the firm who had had the most experience of the new light; and I am indebted to him for all the figures, as well as the other information, I shall present to you.

I understand that the prime object in view by the firm I mention was in the way of increasing the comfort of the *employés* in one of the departments of their works. In this department—viz., the finishing shed—work is carried on day and night by relays of workmen; and as the machinery requires an unusual application of steam (for instance, in steam-jacketed cylinders in dressing and finishing machines), the temperature is much higher than in the other parts of the works. The night men especially complained of the tendency to drowsiness felt by them; and as electric lighting develops scarcely any heat compared with gas, the firm resolved to make a trial of the new illuminant. They made arrangements with a local electric light company, based on the footing that the net annual cost would not exceed the amount they had paid for gas lighting. The electric light company accordingly supplied and fitted up the necessary dynamos (two), shafting, belting, &c., for transmitting the motive power. The engine which drives the machinery of this department is a powerful one, and the addition of the dynamos had no appreciable effect on its working; so that this considerable item—viz., the motive power—was not taken into account. The gas bill for the year from Feb. 1, 1881, to Feb. 1, 1882, for this department, was £75. The following is the account for electric lighting for a like period:—

Gas required for breakdowns or stoppage of engine, &c.	£25	3	0
Fitting up electric light	8	5	0
Attendance	3	18	0
Rent of dynamos and lamps	30	0	0
Carbons	61	0	0
Total	£128	6	0

The shed has a floor space of 15,000 square feet. The lighting was produced by six arc lamps of 2,000 candle-power each. Calculated at this rate, the relative illumination given by gas and electricity was—

Gas—90 burners, each of 20 candle-power... 1,800 candles.
Electric light—6 arc lamps of 2,000 candles.. 12,000 „

Showing an overwhelming advantage for lighting by electricity. But all this great flood of light was not required; so that the financial side of the question impressed itself very forcibly upon the firm, who, whilst desirous of ministering to the comfort of their *employés*, were scarcely prepared to pay such a substantial price for it as the difference of cost—viz., £53. Of the success of their efforts in securing the primary objects of their electric lighting experiment—viz., lowering the temperature in the finishing department—there seems to be no doubt, as the workmen are unanimous in expressing their preference for electric lighting; and personal inquiries made of several of them by myself, with a view, if possible, to find a "chink in the armour," failed to shake this testimony.

Very little importance seems to have been attached to any inconvenience which may have been caused by breakdowns and consequent extinction of the electric light, as they said: "Of course we always keep the gas alight, and are ready for such emergency." As time wore on they became better acquainted with the peculiarities of the new light, and less trouble was caused.

Admitting all this, still the additional expense over gas was unsatisfactory; but as, during the period in question, considerable modifications had been effected in the direction of the expense (especially in the item of carbons, which figured so largely in the last account), my friends hoped that another contract could be arranged, if not with the same electric lighting company, with some other, on considerably reduced terms. They accordingly invited tenders, and one was received from another electric lighting company, whose head-quarters in Scotland are, I understand, at Leith. The following are the terms of the tender for lighting the same sheds as before:—

1 dynamo machine for 10 arc lamps, annual rental	£12	10	0
5 arc lamps, fittings included, at £1 each, annual rental	5	0	0
20 incandescent lamps, at 4s. each, annual rental	4	0	0
Wire and incidental expenses, annual rental	1	10	0
Carbons, at 4d. per foot for arc lamps ......(say)	44	0	0
Total	£67	0	0

This does not provide for any contingencies in the way of an occasional use of gas in the case of repairs, &c.; and I do not think that an additional £10 to this account would be out of the way, seeing that on the previous year's working the sum of £25 was allowed, so that I am giving credit for a great improvement over the previous experiment. The net annual cost of lighting under the new contract will therefore be £77. The gas account, as before stated, was £75; consequently, the new electric light will appear to be practically as cheap as gas, always keeping in mind that no expense is incurred, or at least debited, for motive power.

Along with the above-mentioned tender for lighting the finishing department of the works in question was submitted another, on a larger scale, to light the whole of the weaving-shed and finishing department. In this instance the plant

* A paper by Mr. D. B. Esplin, read before the North British Association of Gas Managers.

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was to be supplied at a sum which purchased it at once off-hand.

16 Brush lamps of 2,000 candle-power nominal, to burn 16 hours, at £16 each	£256 0 0
16 globes, at 12s. each	9 12 0
1 large dynamo machine for above	400 0 0
1 automatic regulator for working with any number of lamps on or off	26 0 0
500 yards of best insulated cable	25 0 0
Carriage, fixing, installation, &c.	75 0 0
Total	£791 12 0

Note.—Carbons, 4d. per foot; engine power necessary for above, 20 horse-power. Annual cost of carbons for above 16 arc lamps, at the rate estimated by the company—viz., 3s. 4d. per hour per lamp for 4,327 lighting hours—£216 6s. 8d.

The account paid for gas used in the works proposed to be lighted with electricity, as per above tender, was £287 for the year from February 1, 1881, to February 1, 1882. If we allow 10 per cent. for wear and tear of the electric lighting plant, this brings the annual cost of the new light up to £295—a small difference in the net cost of the illumination, and, in the opinion of those concerned, amply compensated for by the advantages before mentioned—viz., absence of heat.

Having now placed before you the facts and figures which are the results of an actual experiment on a fairly large scale, I trust I have not occupied the time of the meeting without conveying something of practical interest to the members of the association. It has certainly not been my object to construct before the eyes of my brother managers a house of cards, for the edifying pastime of knocking it down, which I cannot help thinking has pretty often been the case on similar occasions. I have not attempted to enter into the question whether this experiment has paid the electric light company, but have dealt with the accounts as presented. The question may be raised that the circumstances were unusually favourable for an experiment with the electric light, as a very considerable item—viz., motive power—was almost ignored; but there are hundreds of large factories and workshops where powerful engines are already at work, and where a (comparatively speaking) slight additional burden of a dynamo would scarcely be felt. Under such conditions there cannot be the least doubt that electric lighting enters the field under great advantages in competition with gas, and it will be wiser for us to recognise such facts than to pooh-pooh them.

In conclusion, I hope those gentlemen present who have had the superintendence of extensive experiments in exterior or interior electric lighting will supplement the rather scant details which I have given, and help to enlarge our knowledge on a subject so nearly affecting our interests. All will contribute to spur us on to greater efforts to consolidate the valuable industry with which we are identified; and if the rate of progress that has marked it in the past decade is kept up, we have no reason to fear the rapid advance of practical science wherever it affects us, as, side by side with new discoveries threatening to supersede our chief source of revenue—lighting—others are being made which greatly enhance the value of our other products, all ensuring the permanency of our establishments.

CORRESPONDENCE.

EMMENS'S BATTERY.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Can any of your correspondents tell me how to construct the "Emmens" voltaic battery mentioned in a recent issue?—Yours, &c., E. TAGUET.

West End Garden, Great Marlow.

WHITEHAVEN.—The new baths are to be lighted by Swan lamps.

PRACTICAL TELEPHONY.

(CONTINUED FROM PAGE 258.)

DAILY REPORT SHEET.—Each clerk in charge must make up a "daily report" giving the number of calls, both "local" and "through;" also a report sheet of any fault in the apparatus in the switch room or with the subscribers' instruments and lines, as far as they come under notice. All reports of faults should be transmitted to the fault department as soon as received, that they may be attended to without delay.

Daily Report from —— Exchange.

Local Calls.	Through Calls.	Total.
709	86	795

FAULTS.

No. Subscriber.	Description of Fault.	Time.
1,879	Cannot get	9:15 a.m.
1,859	Contact	10: 0 ,,
1,832, 1,729, 1,817	All in contact	10:15 ,,
Switch Room	No. 2 table out of order	11: 0 ,,
1,830	Transmitter defective	3 p.m.
1,806	Humming in transmitter	—

Signed,

Clerk in Charge.

If a head office, the report sheets for that office are made by the clerk in charge as for any other office, and the superintendent makes up a general daily report which gives the number of calls, faults, &c., for all the offices, and is sent into the manager every morning, after the electrician has inserted the cause of the faults, by whom, and the time removed.

Central Exchange.

Name of Exchange.	Local calls.	Through calls	Total.
Central	1,280	200	1,480
Western	670	30	700
Northern	780	126	806
Docks	520	72	592
Sussex Street	320	123	443
Wool Market	106	501	607
Coal Exchange	318	326	644
Stock ,,	732	205	937
Wood Street	220	321	541
	4,946	1,904	6,750

Signed,

Superintendent.

INSPECTORS' DUTIES.—Inspectors should always carry the following tools and articles, which may be fitted into a small pocket case:—

One large screw-driver.
One small screw-driver.
One pair taper-nosed cutting plyers.
One 4-inch smooth flat file.
One small rat tail file.
One three-square file.
Two gimlets.
One pair tweezers.
One bottle sweet oil.
One small slip oilstone.
One small box containing a reamer.
A small wire for oiling, a few double-pointed tacks, a small assortment of screws both for wood and metal; and in the flap of the case
Two spare telephone diaphragms.
A few gummed papers for telephones.
One small coil of paraffined wire.
One small coil of No. 24 silk-covered wire.
One spare telephone cord.
One small camel hair paint-brush for dusting.
Two battery zinc, a packet of sal-ammoniac, and a small

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detector should also be carried, and a useful addition is a medical Lechanché cell in ebonite case (costing 1s. 9d.). This can be joined to the detector direct for testing purposes instead of disconnecting and using the cells at the station where inspecting. The duties are:—At regular intervals (say every three weeks) to examine all the apparatus at each subscriber's office in his district; this includes the earth connections, battery, and leading-in wires. He must be able to do repairs quickly and efficiently, to attend to faults promptly, and, if possible, to remove them before leaving. He should also become acquainted with the construction and use of all telephonic apparatus both in the subscribers' offices and the exchanges, so as to be able to quickly find and remove the cause of a fault. In ordinary inspection, inquire and note if any fault has occurred since the last visit; if so, in addition to the following, search for the particular fault. First examine the battery. Replace any zincs that are nearly eaten through. See that each cell has sal-ammoniac in it. Scrape off any encrusted salts on jar, carbon, or zincs. If necessary, wash out the jars and recharge. Scrape any corroded terminals or connections clean and bright, and see that all the connections are screwed down securely. Take care to drop none of the solution on any of the wires. Follow up the wires to the instrument, and repair if frayed or showing other damage; if loose, staple up. Next inspect the switch-bell and transmitter, screw up any terminals or wire connections that may be loose, see that the bell contact and battery contact posts are firm, brush out, dust, &c., clean all contact points of bell, local cell, telephone, bell switch springs, and carbon contact in transmitter, by drawing a piece of clean writing paper between the contact, at the same time pressing them closely together with the finger. When cleaned, see that they make good, firm contact. The slightest touch of sweet oil may be placed on each rubbing contact with advantage, but the quantity must be very minute (a single drop should oil dozens of instruments). It need scarcely be said that no oil must be put to any part of the transmitter or to any dotting contacts. Next examine the telephone; see that there is no dirt between the pole piece and diaphragm, that the bobbin is tight on the pole piece, that the cord is sound at the terminals. If at all frayed, carefully unwind the covering from the conductor, cut off the frayed ends, double each conductor back a short distance, place the doubled ends in the terminals and screw up. See that the conductor ends do not touch where joined to terminals in bell case. Lastly, ring up the central office. Note how your bell rings in reply, and communicate with them; if all is O K note it in your book, and proceed to your next subscriber. There may seem a large amount of unnecessary detail, but by careful attention in inspection coming faults are often prevented, and an inspector is not valued by the number of the faults that occur in his district.

Removing Faults.—Instructions are here given for locating particular faults, but it is advisible in all cases to go through the inspection as previously directed. In the first place, supposing this has been done, and no fault discovered, proceed to test as directed for the particular fault that is on, but do not alter the least thing until quite sure what you intend doing; look well first.

Bell not Ringing.—See that the screw in contact-post of bell has not worked back; if so, screw it up so that when the hammer is held against the bell the contact spring just leaves the contact screw and no more; also see that the spring which presses out the ringing button makes good contact with the contact bracket connected to the bell; lastly, see that the end of bell coils connected to E is not broken from the hinge, to which it should be soldered. If all these points are seen to, and if necessary repaired, connect the terminals C and L with a wire. This should ring your bell. If it does, and still the other station cannot ring you up, the fault is there. It is supposed in this case that you can call up, but your bell will not ring in reply.

To Ascertain if the Bell at far end of Line is Ringing.—Take telephone off the hook and place it to your ear, join terminals C and L; if the bell is then ringing, at the distant station a drumming corresponding to the make and break of the distant bell is heard. The push button is not to be used in this test.

Bell Rings but cannot Reply.—Battery probably wrong; inspect again, join terminals C and L. If bell rings well, the fault is probably at the other station.

Bell not Ringing, and No Call can be Sent to Other Station. Telephone Works.—Examine and test as before, but the fault will probably be that the contact spring for bell circuit does not make good contact with the switch hook disc; adjust and test again.

Total Breakdown; No Communication by Bell or Telephone.—Join terminals C and L, and see if bell rings; next join terminals L and E, place telephone to ear. If you get a sound upon tapping the transmitter, and the bell rings in answer to the first test, the fault is outside the instrument, and the leading-in and earth wires and other connections must be carefully examined. A temporary earth wire may be connected up to a clean gas pipe. If the fault then disappears, a defective earth connection is the cause; if it does not, and no damage appears in the connecting wires and leads, the line man must go over the line.

Everything Right at Station, but Nothing Through to other Station.—Supposing you are certain the other station is in good order, the fault is caused by full earth on line, either along the route, or the line and earth wires are in contact, possibly from the careless use of staples or the tail end of a wire touching another terminal besides its own. This may have been overlooked in inspecting; or if an exchange line, the exchange connections and annunciator must be carefully tested and examined.

(TO BE CONTINUED.)

A HISTORY OF ELECTRIC TELEGRAPHY TO THE YEAR 1837.

BY J. J. FAHIE, MEMB. SOC. TEL. ENGS. AND ELECS.*

(CONTINUED FROM PAGE 259.)

Chapter III.—Telegraphs Based on Static, or Frictional, Electricity.

Whether Sir David Brewster was aware of these fresh facts we cannot say, but certain it is that, in October, 1859, he accepted the evidence in favour of C. M. being a Charles Morrison, with as much warmth, and, we fear, as much haste, as he had done that for Charles Marshall in the previous December. At page 207 of "The Home Life of Sir David Brewster" (Edinburgh, 1869), Mrs. Gordon says:—"After a good deal of correspondence on the subject, Sir David Brewster gave up all hope of discovering the name of the inventor, and it was not until 1859 that he had the great pleasure of solving the mystery, in the following manner:—He received from Mr. Loudon, of Port-Glasgow, a letter, dated 31st October, 1859, stating that, while reading the article in the *North British Review*, his attention was arrested by the letter of C.M., and having mentioned the fact to Mr. Forman, a friend then living with him, he told him that he could solve the mystery regarding these initials. Mr. Forman recollects distinctly having read a letter, dated 1750, and addressed by his grandfather, a farmer, near Stirling, to Miss Margaret Winsgate, residing at Craigengilt, near Denny (to whom he was subsequently married), referring to a gentleman in Renfrew of the name of Charles Morrison, who transmitted messages along wires by means of electricity, and who was a native of Greenock, and bred a surgeon. Mr. Forman also states that he was connected with the tobacco trade in Glasgow, that he was regarded by the people in Renfrew as a sort of wizard, and that he was obliged, or found it convenient, to leave Renfrew and settle in Virginia, where he died. Mr. Forman also recollects reading a letter in the handwriting of Charles Morrison, addressed to Mr. Forman, his grandfather, and dated 25th September, 1752, giving an account of his experiments, and stating that he had sent an account of them to Sir Hans Sloane, the President of the Royal Society of London, who had encouraged him to perfect his experiments, and to whom he had promised to publish an account of what he had done. In this letter Mr. Morrison stated that, as he was likely to be ridiculed by many of his acquaintances, he would publish his paper in the *Scots' Magazine* only with his initials."

How far this statement may be credited we will not unkertake to say; we would, however, just point out that Sir Hans Sloane resigned the presidentship of the Royal Society in 1741, and lived in strict retirement at Chelsea until his death, which occurred on January 11, 1752, at the advanced age of ninety-two years. It is not likely, therefore, that he would have received, or written, any letters of the above-mentioned nature in the last days of his life. At any rate, a careful search through his papers, which we have instituted in the British Museum and the Royal Society, has failed to discover any.

1767.—Bozolus's Telegraph.

Joseph Bozolus, a Jesuit and lecturer on natural philosophy in the College at Rome, was the next to suggest an electric telegraph, and one in which the spark was the active principle. This

* The author reserves all rights of translation.

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must have been some time anterior to 1767, as we find it familiarly described in a Latin poem,* published in that year.

His proposition was to lay underground two (? insulated) wires between the communicating stations, which may be any distance apart. At both stations the ends of the wires were to be brought close together, without touching, so as to facilitate the passage of a spark. When, under these circumstances, at one end, the inner coating of a charged plate, or jar, was connected to one wire, and the outer coating to the other, the discharge would take place through the wires, and manifest itself, at the break, at the distant end, in the form of a spark. An alphabet of such sparks, Bozolus says, could be arranged with a friend without any difficulty, and a means of communication be thus contrived, which, as tolerably easy, he leaves to each one's judgment to devise and settle in detail.

Bozolus appears to have been a man of varied acquirements. As a sort of diversion from more serious studies, he undertook an Italian translation of the "Iliad" and "Odyssey" of Homer, which Mazzolari, himself no mean poet, praises very highly.

As the "Electricorum" is very scarce, and, therefore, not easily accessible, we present our readers with a faithful transcript of the verses, descriptive of the telegraph, which we have extracted from a copy of the work in the British Museum.

Quid dicam, extrema pendentis parte catenae,
Qui palmam objecit, confestim flamma reluxit,
Tenviaque arguto strepuerunt sibila vento?
Et qui continuos secum prius ordine longo
Disposuit globulos; tum flammam excivit, et ignem
A primo insinuans sollers traduxit ad imum?
Atque hic arte quidem multa omniginaeque Minervae
Instructus studiis vitro impiger instat, et usque
Extundit visenda novis spectacula formis.
Quid? quod et elicitas vario discrimine flammas
Nunquam tentatos idem detorquet ad usus;
Insuetisque notis absentem affatur amicum.
Quippe duo a nexa in longum deducta catena
Aenea fila trahit; spatium distantia amici
Definit certum, verum, quo lumina fallat
Spectantum, et miram quo callidus occulat artem,
Fila solo condit penitus defossa sub imo,
Sic tamen; ut capita emergant tum denique; signa
Conscius opperiens condicta ubi servat amicus.
Ipse autem interea vitri revolubilis orbem
De more exagitans fluctum derivat; et inde,
Qua duo se extrema respectant aenea parte,
Attactum citra et praescripto limite, fila;
Composito tot scintillas educit, ad usum
Quot talem elicitis opus est; quae singula nempe
Designent elementa; quibus in verba coactis
Sensa animi pateant, certa et sententia constet.
Atque his indiciis, fiduque interprete flamma
Absens absentem dictis compellat amicum.

Lib. I., pp. 32—35.

1773.—Odier's Telegraph.

The idea of an electric telegraph appears next to have occurred to Louis Odier, a distinguished physician of Geneva, who thus wrote, in 1773, to a lady of his acquaintance:—

"I shall amuse you, perhaps, in telling you that I have in my head certain experiments by which to enter into conversation with the emperor of Mogol, or of China, the English, the French, or any other people of Europe, in a way, that without inconveniencing yourself, you may intercommunicate all that you wish, at a distance of four, or five, thousand leagues in less than half an hour! Will that suffice you for glory? There is nothing more real. Whatever be the course of those experiments, they must necessarily lead to some grand discovery; but I have not the courage to undertake them this winter. What gave me the idea was a word which I heard spoken casually the other day at Sir John Pringle's table, where I had the pleasure of dining with Franklin, Priestley, and other great geniuses"†

Although, according to Professor Maunoir, Odier was about this time devoting much attention to electricity, we do not find that he ever attempted to carry out his telegraphic idea.

1777.—Volta's (so-called) Telegraph.

At page 243, Vol. I., of *The Journal of the Society of Telegraph Engineers*, we find the following letter:—

"To the Secretary of the 'Society of Telegraph Engineers.'

"Battle, Sussex, July 4th, 1872.

"Sir: I have not met with any statement in English histories, or other English treatises, on the Electric Telegraph, relative to *Volta's* proposed Electric Telegraph.

"Professor L. Magrini, member of a committee appointed to examine and report upon Volta's library, manuscripts, and instruments, published a paper in the 'Atti del Rle. Istituto Lombardo,' vol. ii., entitled, *Notizie, Biografiche, e Scientifiche su Alessandro Volta*. This paper was read at various times, in 1861, at the said institute. It contains a paragraph, of which the following is a literal translation:—

"'An autograph manuscript, dated Como, 15th April, 1777, which is suspected (and the suspicion was confirmed by one of the sons of Volta) to have been addressed to Professor Barletti, contains various experiments on his pistols, and the singular proposition, very remarkable for that time, of transmitting signals by means of ordinary Electricity. Besides the figure, there are particulars conducive to its practical application.

"'This letter is of the greatest interest for the history of the science, inasmuch as it indicates the first bold and certain step in the invention and institution of the Electric Telegraph.'

"Although our Charles Marshall, of Renfrew, in 1753, and others, forestalled this proposition, it is interesting, as proving that the *in re electrica Princeps* believed in the efficiency of frictional electricity for the purpose.

"I am, Sir, your obedient servant,

"G. E. Preece, Esq. "Francis Ronalds."

Now, although, as Ronalds says, and as we have just seen, Volta was not the first to propose an electric telegraph, still we were delighted to learn, on such, apparently, good authority, that the great Italian philosopher had turned his mind to telegraphy at all, and we eagerly sought for some particulars of his plan. After much trouble we succeeded in getting a copy of the letter referred to by Professor Magrini, and great was our disappointment to find that it contained nothing more than the *suggestion* of an experiment which was *carried out* (though on a lesser scale) thirty years before by Lemonnier, Watson, Franklin, De Luc, and others. In order that the reader may be able to form his own opinion on this point we give Volta's original letter, as well as a translation, which we have made from the French of César Cantu, the distinguished Italian historian,* Volta says:—

"Quante belle idee di sperienze sorprendenti mi van ribollendo in testa, eseguibili con questo stratagemma di mandare la scintilla elettrica a far losbaro della pistola a qualsivoglia distanza e in qualsivoglia direzione e posizone! Invece del colombino che va ad appicar l'incendio alla macchina di fuochi artificiali, io vi mandero du qualunque sito anche non diretto la scintilla elettrica, che col mezzo della pistola aggiustata al sito della pianta artifiziale, vi metterà fuoco. Sentite. Io non so a quanti miglia un fil di ferro, tirato sul suolo dei campi o della strada, che in fine si ripiegasse indietro, o incontrasse un canal d'acqua di ritorno, condurebbe giusta il sentier segnato la scintilla commovente. Ma prevegga che un lunghissimo viaggio, dè tratti di terra molto bagnati, o delle acque scorrenti stabili rebbero troppo presso una communicazione e quioi devierebbe il corso del fuoco elettrico, spiccato dall uncino della caraffa per ricondursi al fondo. Ma se il fil di ferro fosse sostenuto alto da terra da pali di legno qua e là piantati, ex. gr., da Como fine a Milane; e quivi interrotto solamente dalla una pistola, continuasse e venisse in fine a pescare nel canale naviglio, continua col mio lago di Como; non credo impossible de far lo sbaro della pistola a Milano con una buona boccia di Leyden, da me scaricata in Como."

"The more I reflect, the more I see the beautiful experiments that can be made by means of the spark in exploding the electric pistol at any distance. An iron wire, stretched along the fields, or roads, for I know not how many miles, could conduct the spark. As, however, in long distances moist earth and watercourses would be encountered, which would draw off the electric fire, the wire may be supported on posts placed at regular intervals, say from Como to Milan. At the latter place its continuity would be interrupted only by my electric pistol, from which it would pass into the canal, which communicates with my lake at Como. In this case I do not believe it impossible to explode my pistol at Milan when I discharge a powerful Leyden jar at Como" [through the wire].

"According to this document," says Cantu, "it is incontestable that Volta had in mind an electric telegraph, half a century before those [alluding to Ampère] who have been proclaimed its inventors. The basis of this astonishing discovery lies in the possibility of transmitting to a great distance the electric virtue, and there causing it to manifest itself in signs. Now this is what Volta had clearly perceived, and, further, he indicated a plan, which is to-day universal, of insulating the conducting wire on posts."† Perceiving a fact, or principle, and applying it,

* "Electricorum," by Josephus Marianus Parthenius (*i.e.*, G. M Mazzolari), Libri VI., 8vo., Romae, 1767.

† "Chambers's Papers for the People" 1851, Art: *Electric Communications*, page 6. Also Dodd's "Railways, Steamers, and Telegraphs," London and Edinburgh, 1867, page 226. Odier took out his degrees at Edinburgh, where he might well have read, or heard, of C. M's letter in the *Scots' Magazine* of 1753.

* See *Le Correspondant*, a French scientific periodical, for August, 1876, p. 1059, also *Les Mondes*, for December 5, 1867, p. 561.

† *Le Correspondant*, page 1060, in the course of a somewhat effusive letter on Italy's claim to the discovery of the electric telegraph, Cantu relates the following interesting particulars. The apartments, which Volta occupied at Como, were, for a time, preserved in the state in which

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are two very different things. Gray, Dufay, Watson, and all those who made experiments on the transmission of electricity long before Volta, perceived the same fact as he did, and, like him, missed its application. To say then, as Professor Magrini does, that Volta's letter indicates the first bold and certain step in the invention and institution of the electric telegraph is to assign to it a meaning which it was never, we believe, intended to convey; and we are the more confirmed in this opinion by the fact that, although Volta lived to the year 1827, and must have heard of the numerous telegraphic proposals made up to that time, he never claimed to have done anything in that way himself.

(TO BE CONTINUED.)

THE GLOBE TELEGRAPH AND TRUST COMPANY (LIMITED).

The tenth ordinary general meeting of this Company was held on the 27th ult., at the City Terminus Hotel, under the presidency of John Pender, Esq., M.P.

The SECRETARY (Mr. Wm. Payton) having read the notice calling the meeting, and the minutes of the previous annual general meeting, which were confirmed by the present meeting, and signed by the Chairman as correct,

The CHAIRMAN said: It is ten years since this Company was established, and the accounts that we now submit at the end of the decade I think we may consider as of a very satisfactory nature. We are paying you a dividend of 4¾ per cent. on the ordinary shares, as against 4½ per cent. last year. Taking the dividends from the commencement of the Company, and this present dividend to be paid to-day, which is the fortieth dividend, we find that we have paid in addition to our 6 per cent. preference dividend an average dividend of 4½ per cent. on our ordinary shares, that is together an average of 5¼ per cent. on the preference and the ordinary in combination since the Company's formation. In looking back I am glad to find that what we put forward in our original prospectus has been fairly fulfilled. We have in the Globe Company a combination of all the important telegraph systems connected with England, and I am glad to say at the present time that all the cables of these companies are in good working order, probably for the first time for some years. That is another satisfactory feature in the present state of our Company; for, as you know, our dividends depend entirely upon the dividends paid by these different telegraph companies. I am also glad to say that, notwithstanding the extraordinary competition and agitation which have from time to time been raised in connection with Atlantic telegraphy, yet, through the other systems, our dividends have been steadily maintained, and this has counterbalanced any drawback that may have taken place from that cause. Our investments now are all fairly prosperous. Our general submarine cable system has steadily progressed, as will be manifest when I tell you that while in 1870 there was something like 30,000 miles of cables, now in 1883 we have 82,000 miles of cable laid, showing an enormous increase in that period. We had in the former period something like ten millions sterling, while to-day we have thirty millions of capital invested in submarine telegraphy. This large development in telegraph property shows very clearly that a company like this was almost a necessity, and that it was of advantage has been established by the steady progress which it has made, and the confidence which the public now have in it as an investment. Last year, when I had the pleasure of addressing you, we were on the threshold of a war with Egypt. I referred to it then, and I refer to it now as an important era in telegraphic enterprise. I believe, and I have it on the very highest authority, that had it not been for the enterprise shown by some of the telegraph companies on that occasion, the war, which terminated so quickly and so favourably, might have gone on and cost this country millions more than it did cost. I may also mention that during the last year one of the companies in which we are interested has laid a triplicate cable in the Red Sea. Austria has been connected with Egypt by submarine cable, and another of the companies has completed a line to China. All this adds to the revenues of the respective companies in which we are interested. I make these remarks simply to show you that the different telegraph companies in which we are interested so largely are all in a thoroughly satisfactory and progressive position, and I am hopeful that they will continue so, for while they continue to progress, we cannot possibly go back. Now gentlemen, I am not going to trouble you with a long speech, because I said so much this time last year that I think it almost unnecessary to say anything further on this occasion except this, that probably at no time could I speak with more confidence of telegraph property as a property than I do to-day. We find now that we can pick up cables at almost any depth of water, and when we do pick them up we find that decay, as regards the real heart of the cable, is infinitesimal. Consequently we have established the fact that a telegraph cable is a good property. It is a property that will always be considered more or less speculative, but the fact of its being considered more or less speculative gives it a higher rate of interest than almost any other investment. I know with regard to the money that we have to invest for reserve funds that we find great difficulty in getting much more than 3¼ per cent. or 3½ per cent., and on telegraph property you now receive from 5¾ per cent. to 6 per cent., that is on the general amount of telegraph property which we hold. With these remarks I beg to move "That the report and accounts of the directors for the year ending July 18, 1883, submitted to this meeting be, and they are hereby received and adopted, and that the following dividends be now declared payable this day, viz.:—3s. per share on the preference shares, making, with previous quarterly payments, 6 per cent. for the year ending 18th July, 1883, and 3s. 6d. per share on the ordinary shares, making, with previous quarterly payments, a total dividend of 4¾ per cent. for the year ending the same date."

Sir DANIEL GOOCH, Bart., M.P.: I have much pleasure in seconding that.

The CHAIRMAN then invited discussion, and a shareholder made inquiry as to payment of income-tax by preference shareholders, to which the chairman replied that as the income-tax on dividends was deducted from them by the respective companies before the dividends reached him, he, as trustee, only had to pay over the dividends as they were received in the proportion of 6 per cent. to the preference and the full balance to the ordinary shares, after expenses. The chairman then put the motion in the usual way, and it was carried unanimously.

Sir DANIEL GOOCH then moved the following resolution:—"That Mr. John Pender, M.P., be and he is hereby re-elected a director of this Company."

The Marquis of TWEEDDALE seconded the motion, and it was carried unanimously.

The CHAIRMAN next moved:—"That Sir James Anderson be and he is hereby re-elected a director of this Company."

Mr. H. D. GOOCH seconded the motion, which was carried unanimously.

Sir JAMES ANDERSON having returned thanks,

A SHAREHOLDER said he observed that the Company had taken its allotment of 11,830 shares of the recent issue of the Eastern Extension Company at £11 a share. He did not see where they had got the money to do it with.

The CHAIRMAN: I am glad you put the question. I did not refer to it, but I thought that some one in the body of the room would ask me a question about it. When the Eastern Extension Company issued these fresh shares, we were entitled to a certain number of them, and we took up the number. We could have paid for them at once by placing an equivalent number of our own shares upon the market, and realising sufficient to pay for the allotment; but we saw considerable progress in our Company, and we saw that in taking up the transaction there might be something like £11,000 to the good, and as we could arrange without any difficulty to get the money we required for this purpose at 4 per cent., and we were getting 6 per cent. on the shares, we thought it not a bad operation. This, however, would scarcely justify us in making this purchase if we had not the money to pay for it, but as it is really the principle in this Company to issue our shares in exchange for others, we thought this transaction perfectly right. There is a considerable improvement already in the value of the Globe shares, and when they go up a little more we shall place them on the market, and the proceeds will pay off that £130,000. In the meantime, we are making 2 per cent. by the transaction, and I hope, in addition to the 2 per cent., that when we close it we shall be able to show a balance to the good of £11,000 on the transaction.

Mr. NEWTON moved—"That Mr. J. G. Griffiths, F.C.A., and Mr. William Griffith, B.A., barrister-at-law be, and they are hereby re-elected auditors of the Company for the current year, with a remuneration of thirty guineas each."

Mr. OAKES seconded the motion, which was carried unanimously.

Mr. GRIFFITH thanked the shareholders for his re-election, and observed that it had been a pleasure as well as a duty to investigate the accounts. They were well kept, and he could testify that the securities were in good order. He thought they might congratulate themselves on the state of the Company, which had no doubt gained confidence with the public. Their preference shares had become a more popular and stable investment for permanent purposes. He (Mr. Griffith) acquiesced in the view of the chairman, that the dividends in this Company had already paid income-tax. They had all reason to be thankful for the condition in which the Company was, and for that condition they were indebted to the good management which had been exercised. As far as the auditors were concerned, they could say that they thought the Company sound, *bonâ fide*, and steadily progressing. In conclusion, he moved a vote of thanks to the chairman and directors for so ably presiding over them. There was no doubt that the chairman's connection with telegraphy from its early inception, and the progress of which he had so closely watched, had materially contributed to the success of the Company. The chairman's experience was greater than that of most men. His influence was great both in a parliamentary and commercial sense.

The motion having been seconded, it was carried unanimously.

The CHAIRMAN: I beg to thank you on behalf of my colleagues and myself. I can only say that, looking at the gentlemen sitting on this side of the table, there is no question that we do understand something about the securities of which we are trustees. We have a duty perhaps a little beyond simply receiving and paying these dividends to you. We have to watch the progress of these companies, and to see that our investments are what I would call sound, and also to bear in mind that upon soundness and permanency depend our dividends in this Company. We are trustees, and we try faithfully to perform the duties of our trust. We are obliged to you for your confidence in us.

THE DIRECT SPANISH TELEGRAPH COMPANY (LIMITED).

An extraordinary general meeting of this Company was held on Friday, the 27th ult., at the Cannon-street Hotel, Mr. Neil Ballantyne in the chair.

Mr. CH. GERHARDI, the manager, having read the notice convening the meeting,

The CHAIRMAN said he would take the two resolutions which he had to

he left them at his death (March 5, 1827). There one could see his books, papers, machines, even his tobacco pouch, spectacles, decorations, and cane; in short, everything that becomes a sacred relic when death has removed him who used it. Amongst the pieces of apparatus, were all those which he had himself invented, including the first pile, and that which he took to Paris, in 1801, when invited by Napoleon to repeat his experiments before the Institute.

In consequence of the pecuniary embarrassments of Volta's sons, these precious relics were in danger of being dispersed, when the Academy of Sciences of Lombardy stepped in, and, while it assisted the sons, honoured the father. The whole collection was purchased for 100,000 livres, and lodged in a chamber of the palace of Brera at Milan, where, under the appellation of *Cimeli di Volta*, it is preserved with reverent care.

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submit to the meeting. The first in order was based on the first paragraph in the notice which had been read, and he would, in the first place, read the resolution, which he would conclude by moving:—"Resolved, that the directors be, and they are hereby authorised to establish, maintain, and work a submarine cable in duplication of the Company's existing cable between England and Spain, and to raise the capital necessary for that purpose by exercising the powers of borrowing vested in the directors by the regulations of the Company." He had not much to say upon this resolution, but would just make one or two explanatory remarks before putting it to the meeting. He did not know whether any of the shareholders who were now present were present on the occasion of the last meeting, when Mr. Etlinger occupied the chair, and went into a very minute and detailed report upon the position of the Company and upon the misfortunes with which they had met in reference to the repeated breakages of the cable; but he thought those shareholders who were then present would not be surprised that the directors had called them together for the purpose of passing this resolution. The subject had been one which the Board had very frequently and very deliberately considered, and it had given them, of course, a good deal of anxiety as to what steps they should take and when they should take them. He might state the amount of money that had been spent upon the repairs since the cable began to be insured. It amounted for 10¼ years to close upon £25,000, which they might take in round numbers to be about £2,500 a year. But that, of course, was not the only loss that the Company had sustained by these breakages. There had, of course, been the interruption of their traffic, and the loss sometimes for a considerable period—at least for some period even after the cable was repaired, because it was not so easy to get traffic back again after the cable had been up for six weeks or two months. No doubt, since they entered into a working arrangement with the Eastern Company, they had not suffered to the same extent they otherwise would have done while the cable was down, but still, even with the advantages of their working agreement with the Eastern Company, they could not help losing a certain amount of traffic. It was not so easy to get all their customers or the public generally to send their messages while their cable was down by the Eastern, which they recommended them to do. A certain portion went round by the Submarine, and he should say that, taking the actual outlay for repairs—taking their loss of traffic directly and indirectly—that they would not be over the mark if they were to say that, in addition to the £2,500 a year, they had lost probably £1,500 or £2,000 per annum.

Mr. GERHARDI: More.

The CHAIRMAN: That was the minimum; therefore it became their duty seriously to consider whether it would not be for the advantage of the Company—for the shareholders, both preference and ordinary, especially the ordinary, that they should duplicate the cable, and they had much discussion about the matter, and gave great consideration as to how they could accomplish this, and what would be the result. Well, they had seen their way, he thought, to state to the shareholders that, if they raised the necessary money to lay this duplicate cable, which they did not anticipate any difficulty in when they came actually to carry the thing out, they would be able without looking to a very great increase of traffic—they did expect they would have an increase of the traffic by and by, as things were better in Spain, at all events they knew the minimum of traffic that they might expect even in the worst times, making a fair calculation for the future—they expected to be able to pay the interest upon the money that they would raise to lay this duplicate cable. They would be able to pay all their working expenses of course, and they would have left an amount sufficient to give a fair dividend to the ordinary shareholders, as well as to put a moderate sum every year to reserves. It was the unanimous opinion of the Board, and of some very large and influential shareholders who had entered the Company since the last meeting, and who, in fact, held the preponderance of the ordinary capital of the Company, that they should, at as early an opportunity as convenient, make the necessary arrangements for having a new cable made and laid.

A SHAREHOLDER asked how much of the proposed capital they proposed borrowing.

The CHAIRMAN replied that they could not say the exact amount, because they could not say beforehand the precise amount for which they would be able to make the contract for the cable. They believed the interest would probably not be over, but something like £4,000 a year, which he was quite sure was a smaller sum than what they had lost per annum since the cable began to work. His own opinion was that if they had a duplicate cable once laid the Direct Spanish Telegraph Company would hold a very strong and good position. He might mention that since the last repairs were finished the cable had been working most satisfactorily, and its electrical condition up to the date of last advices was very good. Of course they could not say what its mechanical condition might be, because they had no way of ascertaining. He hoped it would continue to work, but still it was absolutely necessary to their security, and would really promote the progress of the Company, if they duplicated the cable whenever they could see their way to do it. In the meantime they thought it advisable to take the authority of the shareholders in order that they might carry it out whenever circumstances were especially favourable to their doing so. They could not lay the new cable this year, because the weather in September and October was so rough in the Bay of Biscay that it was not at all a time of year when it was advisable to conduct an operation of that kind, but they would like to be in a position to take advantage of the first fine weather in the spring. Meanwhile, if anything happened they expected to be able to have their cable repaired on much more favourable terms than they had hitherto had them done at.

The resolution was then put, and carried unanimously.

The CHAIRMAN said that in proposing the first resolution he took occasion to mention that since the last meeting a very large number of ordinary shares had passed into the hands of new holders. The directors had had friendly conferences with the representatives of those holders on several occasions, and he might say that their only desire was to promote the prosperity of the Company. They were largely interested in the Eastern Company, with whom this Company had a working arrangement, and it was thought to be of great importance that the bonds of unity should be drawn closer together. The Eastern Company had a very large amount of cable under its control and management, and was a very wealthy company. They had men connected with them who had very great experience in the management of submarine cables, and it was thought that it would be for the benefit of the Direct Spanish that one or two gentlemen should be introduced on to its Board more or less connected with the Eastern. The directors were very glad to receive the two gentleman proposed. Sir James Anderson was the manager of the Eastern, and had had great experience in submarine cables, while Mr. John Denison Pender, a young man, was the son of the chairman of the Eastern, and he believed a director of the company also. He therefore had great pleasure in proposing "That the number of the directors of the Company be made up to five, and that Sir James Anderson and Mr. John Denison Pender be and they are hereby elected directors."

Mr. ABRAHAM SCOTT seconded the motion.

Mr. ATRELL asked what was the remuneration of the directors?

The CHAIRMAN replied £400 a year among them.

Mr. ATRELL: Among the five?

The CHAIRMAN said that so far as he had to say anything in the matter, and he believed his colleagues and the two new directors would be of the same opinion, the addition to the Board would impose no additional burden on the Company. The directors' remuneration would remain the same.

Mr. ATRELL thought that as the Company had got into so much difficulty it was a question whether it would not be policy to liquidate or offer the undertaking to the Eastern. There was no doubt that the Eastern Company would give them a fair value for their property. He did not see what prospect they would have with £70,000 of additional capital.

Mr. ETLINGER: Don't you think it would be wise to have an offer first before you liquidate?

Mr. ATRELL had no objection, but should like the matter to be broached to the Eastern Company, and then they would know what their views were. If the Eastern were to absorb them it would save the expense of a board of directors and various officials.

The CHAIRMAN said that of course they could not take any action at this meeting upon a proposal of the kind, but the resolution they had passed would facilitate any arrangement of the nature indicated should the Eastern Company be prepared to treat with this Company on that footing. However, there was a great deal to be said against what the gentleman proposed if they were going into the matter, but really it was not part of their business that day.

Mr. ATRELL said that he threw the matter out as a suggestion.

The CHAIRMAN said that what the directors looked at was what was best in the interests of the shareholders of this Company. They must remember that the two telegraph companies were only two parties, there were other parties who would have something to say. They had relations with the Spanish Government, upon whom they depended to a great extent for their success, and it was very questionable whether the Spanish Government would be a consenting party to the sale of the Direct Spanish, or to its being handed over to another company. He merely mentioned that in passing, to show that it was not so easy to arrange a matter of this kind.

Mr. HUNTER asked whether there was any intention to practically hand over the control of the Direct Spanish Company to the Eastern Company.

The CHAIRMAN replied that the control of the Company would still remain with the majority of the original shareholders. The directors had no desire or intention to hand over the control of the Company to the Eastern, but they expected to benefit by the counsel and aid of the Company.

The motion was then put and carried.

A vote of thanks to the chairman and directors terminated the proceedings.

THE SUBMARINE TELEGRAPH COMPANY.

The half-yearly general meeting of this Company was held on Thursday, Aug. 2, at the offices, 2, Throgmorton-avenue, London-wall, Sir Julian Goldsmid in the chair.

Mr. S. M. CLARE (the secretary) read the notice convening the meeting, and the report of the directors was taken as read.

The CHAIRMAN having expressed the deep regret of himself and colleagues at the death of Sir James Carmichael, said that he had to call attention to a very marked diminution of income. The receipts amounted to £64,332, which was less by £6,009 than the amount received in the corresponding period of the year 1882. That he must say was practically entirely and absolutely beyond their control; they had nothing to do with the amount of receipts—all they had to do with was the amount of expenditure. That, to a certain extent, and only to a certain extent, might be and was under their control, but the amount of receipts was not in any way to be controlled by the Board. They had pointed out three reasons for the reduction in the receipts, and those three reasons had all had their share; but the reason which was put last was to his mind the one which was of the greatest importance, namely, the reduced length of messages. Upon that point he thought it was right to inform the shareholders the exact state of the case. In the six months ending June, 1882, they transmitted 1,312,240 messages containing 17,427,814 words, in the corresponding period which was just closed, namely, to June, 1883, they had transmitted 1,337,009 messages, containing 16,925,163 words, therefore they had transmitted 24,769 more messages, but they had at the same time sent 502,651 less words, showing the falling off of that very large number of words, and therefore the average length of messages was so much less. The average length in the first period was 13¼ words, whereas for the period to June, 1883, it was 12¾, consequently that simple fact showed to a very great extent the reason for the large reduction of receipts. It showed that people through the press of business were enabled to compress their telegraphic thoughts, or else they had by some means or other found means of communicating to their friends and correspondents by condensing their ideas in some way. With regard to the other reasons for the diminished revenue, those he thought must speak for themselves. There had been a small increase in the number of messages, but he thought hardly an average. There had also been a very long period during which the two Government cables in Holland were simultaneously interrupted. They had to move three cables, and keep them in repair, but

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they had been for some time in bad order. They ran in a line somewhat dangerous to the life of a cable, and the consequence was they involved heavy repairs, and they had also occasioned a loss of revenue. These circumstances accounted for the diminution of receipts. Next they came to a fact which accounted for a diminution of dividend, viz., that they put a larger sum to reserve fund. As one or two proprietors had addressed him upon the subject of the reserve fund, he thought it right that he should explain how the matter stood. In June, 1863, 10 per cent. of the gross receipts were added to the reserve fund for the first time, and it was continued till February, 1873, when it was resolved to reduce the amount to 5 per cent. Individually he disapproved of that policy, and probably it would be remembered that there was considerable agitation from some of the shareholders with regard to the sums put to reserve, and the late Sir James Carmichael was rather of opinion that the directors ought not to guide the shareholders in the matter. Upon that he (the chairman) differed. Later on sounder views again prevailed, and it was resolved that instead of adding 5 per cent. 10 per cent. should be added in the future. So matters remained until the meeting last February, when it was resolved to increase the amount from the 1st June, 1883, to 15 per cent. of the gross receipts. Accordingly the Board were now obliged to add that amount to the reserve, and that policy having been adopted, he should, at any rate for the present, advise them not to depart from it, as it would strengthen their position in the future. It made a difference on the present occasion of about three-quarters per cent. on the dividend. If at the termination of their concession they were able to make arrangements with regard to future operations, then they must consider the advisability of reducing the amount added to the reserve fund. They had done their best to put the Dutch cable into proper working order, but it was not in a satisfactory condition, and they had called the attention of the authorities to its state, and they, in conjunction with the Company, are considering what was best to be done. Referring to the vacancies on the Board, he said that it was intended to keep one seat open, with the view of offering it to Sir Arthur Otway, who he hoped would be induced to join the Board before the next meeting. Mr. Chandos Leigh, a parliamentary counsel, and a man of considerable experience in all public matters, was the only person who had offered himself for the other vacancy. In conclusion the chairman moved the adoption of the report.

Mr. GEORGE C. CAPPER having seconded the motion,

A short discussion ensued, in the course of which the chairman said that the relations with the Post Office were of a most friendly character, and any little matters, if there had been any in dispute, had been amicably settled.

The report was adopted, and a dividend declared at the rate of 14 per cent. per annum.

The Hon. E. Chandos Leigh, Q.C., was appointed to a seat at the board, after which, the retiring auditors having been re-elected, a vote of thanks to the chairman and directors terminated the proceedings.

THE NATIONAL TELEPHONE COMPANY.

Report of the directors for the year ending 30th June, 1883, to be presented to the shareholders at the third annual ordinary general meeting of the Company, on August 9th:—In placing the report of the proceedings of the Company for the last year before the shareholders, the directors have the satisfaction of being able to give conclusive indications of its prosperous growth and sound character. Capital expenditure for the year has been £43,047 16s. 5d., as against £42,360 13s. 1d. last year. The receipts from subscribers have increased, so that the gross revenue allocated to the year ending the 30th June, 1883, is £34,562 3s. 2d., against £19,243 10s. 11d., allocated to the preceding year, whilst the amount allocated and carried forward to the next year's revenue is £24,089 10s. 6d., against £15,643 5s. 5d. carried forward last year. The annual gross revenue of the Company at the end of June, 1882, was £26,996 3s. 10d., and at the end of June this year, £43,111 5s. 6d., of which £4,988 10s. 3d. has been obtained during the last three months alone, and there are satisfactory reasons for expecting similar progressive development in the future. At the time of our last report nine exchanges only were included in the productive list, whilst since then all the twenty-six exchanges of the Company have been placed in that category, thus justyfying the anticipation put forth in last year's report. Last year £144 9s. 8d. was carried forward to the next account after providing the dividend on the preference shares. This year the profits of the Company enable your directors to pay the dividend of 6 per cent. upon the preference shares, and to carry forward a balance of £2,530 16s. 6d. Your directors desire to state that this result has been arrived at after deducting £684 10s. 6d., loss on trunk wires taken from the Postmaster-General. Owing to a more liberal arrangement of the post office terms for trunk communication, it is anticipated that a similar loss will not recur, whilst on the other hand there is a probability of some profit being derived from the trunk system. They also desire to point out that, owing to the establishment expenses being reduced in their pro rata incidence by the growth of the business, a larger proportion of the gross receipts will become net revenue each half year. The Company being brought into continual contact with the great department of which the Postmaster-General is the chief, it is with pleasure that your directors are enabled to inform you that the action of the department is marked by willingness to consider and accept proposals calculated to diminish the restraints upon telephonic enterprise when this can be done with advantage to the public and without detriment to the Post Office revenue. The relations of the Company with the United Telephone Company, which has the arduous task of defending the telephone patents, are of the most satisfactory character, and your directors have pleasure in stating that the United Company has so far succeeded in maintaining the validity of its patents, and checking the hostile proceedings of those who have sought to invade its rights. The retiring members of the Board are, Messrs. William Hardwicke Bradbury, of London; William Lowson, of Dundee; and Samuel de la Grange Williams, of Birmingham; who, being eligible, offer themselves for re-election. The auditors, Messrs. Quilter, Ball, and Company also retire, and are eligible for re-election.

COMPANIES' SHARE LIST.

TELEGRAPHS.

COMPANIES.	CLOSING PRICES AUG. 1.		BUSINESS DONE WEEK ENDING AUG. 1. Highest.	Lowest.
Anglo American	47¾,	48	48½	47¾
Do. Preferred	78½,	79	79¾	78
Do. Deferred	17½,	17¾	18	17
Brazil Submarine	11¾,	12	11 15-16	—
Cuba	10½,	11	10⅝	—
Do. Preference	17½,	18½	—	—
Direct Spanish	5½,	5¾	—	—
Do. Preference	15¾,	16½	16½	—
Direct United States Cable	12½,	12½	12½	12⅜
Eastern Telegraph	10 11-16,	10 13-16	10 15-16	10 11-16
Do. 6 per Cent. Preference	12⅝,	12⅞	12⅞	12⅜
Do. 5 per Cent. Debentures, 1899	105,	108	—	—
Eastern Extension	11 5-16,	11 7-16	11 9-16	11⅜
German Union	9½,	10½	—	—
Globe Telegraph and Trust Company.	7 7-16,	7 9-16	7 9-16	7 7-16
Do. Preference	12¾,	13	12 13-16	12¾
Great Northern	12½,	12¾	12½	—
Indo-European	32,	33	—	—
Mediterranean Extension	1½,	1¾	1½	—
Do. Preference	3,	4	—	—
Reuter's	9½,	10	—	—
Submarine	240,	250	—	—
West India and Panama	15-16,	1 1-16	1	—
Do. 1st Preference	6½,	6¾	—	—
Western Brazilian	6,	6½	6⅛	5⅞
West. Union 7 per Cent. 1st Mortgage	122,	124	—	—
Do. 6 per Cent. Sterling Bonds	103,	106	—	—

TELEPHONES.

Consol. Telephone and Maintenance	⅜,	½	—	—
Oriental	5-16,	7-16	⅜	—
United Telephone	8½,	8¾ x all.	9½	8½ x all

ELECTRIC LIGHT.

Anglo-American Brush Lgt. (£7 paid).	3⅝,	3⅞	4	3⅞
Do. (fully paid)	6¾,	7¼	7	—
Hammond Light	1¾,	2	2¼	1 11-16
Swan	2,	2¼	2¼	2 1-16
Maxim-Weston	1-16,	3-16	—	—

MISCELLANEOUS.

Telegraph Construction	33,	33½ x d.	34⅝	33⅜
India Rubber, Gutta Percha, and Telegraph Works	29,	30	30⅜	—

TRAFFIC RECEIPTS FOR JULY, 1883.

COMPANIES.	July, 1883.	July, 1882.	Incrse.	Decrs.
Anglo-American Telegraph Company	—	—	—	—
Brazilian Submarine Company	—	—	—	—
Cuba Submarine Company	2,700	2,921	—	221
Direct Spanish Telegraph Company	—	—	—	—
Direct United States Cable Company	—	—	—	—
Eastern Telegraph Company	—	—	—	—
Eastern Extension Telegraph Company	36,177	30,070	6,107	—
Great Northern Telegraph Company	—	—	—	—
Submarine Telegraph Company	—	—	—	—
West Coast of America Telegraph Company	—	—	—	—
Western and Brazilian Telegraph Company	—	—	—	—

BOOKS RECEIVED.

Die Elektrischen Uhren und die elektrische Feuerwehr-Telegraphie. Nach dem Standpunkte der Gegenwart geschildert von Dr. A. Tobler. Wien. Pest. Leipzig: A. Hartleben.

Die Elektrischen Leitungen und ihre Anlage für alle Zwecke der Praxis. Von J. Zacharias. Wien. Pest. Leipzic: A. Hartleben.

Annual Report of the Chief Signal Officer to the Secretary of War for the year 1880. Vols. I. and II. Washington Government Printing Office.

Philipp Reis, inventor of the Telephone: a Biographical Sketch. By Silvanus P. Thompson, B.A., D.Sc. Professor of Experimental Physics n University College, Bristol. E. and F. N. Spon.

NUMBERS OF "THE ELECTRICIAN" OUT OF PRINT.—The following numbers of *The Electrician* are out of print, and cannot be supplied at the office, viz.:—Vol. 1, Nos. 3, 9, 19; Vol. 7, Nos. 8, 10, 12 to 18, 20, 21, 24 to 26; Vol. 8, 1, 3, 6 to 12, 15 to 26; Vol. 9, Nos. 2, 4, 24, 25; Vol. 10, No. 13.

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NOTES.

Cork Exhibition.—The hall is lighted by three arc lights.

Litigation in France.—The Edison Company has commenced an action against M. Maxim.

The Pilson-Joel Company.—The application to wind up this company has been dismissed, with costs, by Mr. Justice North.

Chelsea.—Messrs. Crompton and Company are extending the electric lighting at the well-known business house of Peter Jones.

Great Northern Telegraph Company. — Telegraph stations have been opened at Nanching, Hangchow, Ningpo, and Shauhing.

Vienna Exhibition.—It is stated that the exhibition will open on the 16th, but many of the exhibits will, we fear, not be ready even at that date.

British Guiana. — Telegraphic communication with British Guiana is interrupted, the cable between Demerara and Trinidad being broken.

The "Dandalo".—A bulkhead of the Italian ironclad "Dandalo" was set on fire, it is said, by a short circuit in the electric light wires. The damage was very slight.

The Mansion House.—The Egyptian Hall, where the Lord Mayor's banquet to Her Majesty's Ministers took place on Wednesday evening, was brilliantly lighted by the electric light.

The SS. "Clan Macintosh."—This vessel, built by Messrs. Scott and Co., of Greenock, for Messrs. Cayzer, Irvine, and Co.'s Clan line, is to be lighted by 110 lamps on the Edison system.

Alteration of Name of Firm.—Mr. White having retired from the firm of Laing, White, and Wharton, and Mr. Down having been taken into partnership, the firm will henceforth bear the title of Laing, Wharton, and Down.

The SS. "Takapuna."—Edison's system of lighting is applied throughout this vessel, which has been built by the Barrow Shipbuilding Company for the Union Steamship Company, of New Zealand. The trial trip was taken last Saturday.

Cricket.—The Bowater Cricket Club (Siemens Brothers, intrument makers) played their return match with R. E. Crompton and Company's men on Bank Holiday, at Clock House Field, Old Charlton, S.E., when the former scored 155 in one innings, and the latter 72 in one innings.

Signalling in the Navy.—Advantage is often taken when a ship is at anchor off the fort to experiment with the electric light from Sheerness. Thus, a few days ago the ironclad "Repulse" was at anchor between the Nore and Mouse lights, and a course of signalling operations was carried on for a considerable time with great success.

The Electric Lighting of Chelsea.—The discussion on this subject continues to be carried on with some warmth. In *The Times* of Wednesday, Mr. Mossop, chairman of the Chelsea Electric Lighting Committee, replies to some remarks of Lord Bury; and the day following the secretary of the Jablochkoff Company interposes, protesting against the unfair treatment which he considers his company has been subjected to.

Liege.—The Liege International Bell Telephone Company, which was founded in 1880, has now adopted the style of *Compagnie Liegeoise de Téléphone Bell*, and has now incorporated with itself the old and rival Bede Company of that town. A circular, dated 1st August, has been addressed to the old subscribers, offering to replace the Bede by the Bell instruments and effect the junction, all at the company's expense, thus giving more extended communication at the same rates of subscription.

Telephone Exchange and the Post Office.—We learn from the Postmaster-General's annual report that the Telephone Exchange at Newcastle, to which there are upwards of 200 subscribers, has connecting lines to Sunderland, South Shields, Tyne Docks, North Shields, &c., and is worked with great success. Also that the nine companies to whom licenses have been granted for the establishment of telephone exchanges have now 47 exchanges in operation, viz., 37 in England, 8 in Scotland, and 2 in Ireland.

Telegraph Boy Messengers.—The annual summer outing of the telegraph boys was held on Monday, when a large number of them, under the direction of Inspector Howard and Inspector Higham, availed themselves of the invitation of Mrs. Poland, of Florence Lodge, Streatham, to visit her grounds. A number of races and amusements were provided. The boys of the Central Station carried off the principal prizes, those of the Eastern Central Station winning the tug-of-war. The prizes were presented by Mrs. Poland.

York.—The Council of the Yorkshire Fine Art and Industrial Institution, at a meeting held on the 1st inst., passed the following resolution in connection with the exhibition held recently:—"Resolved that the council expresses its satisfaction at the very effective manner in which Messrs. Crompton and Company lighted the great hall and grounds with their electric light during the week commencing July the 16th, on which occasion a grand *soirée* was held, and honoured by the presence of H.R.H. the Prince of Wales."

Liverpool.—During the *soirée* of the British Medical Association on Wednesday in last week, the great hall of the Brown Museum, and the central portion of the Mayer Museum, Liverpool, were effectively lighted by Swan incandescent lamps. The current was supplied from accumulators furnished by the Electrical Power Storage Company, the necessary arrangements being made under the superintendence of Messrs. Holmes and Vaudrey. The Picton reading room was lighted, as usual, by Serrin arc lamps and plant belonging to the Corporation.

Female Telegraphists.—In the House of Commons on Tuesday Mr. Fawcett stated in reply to Mr. S. Maclver that he was not aware of giving any assurance that female telegraphists would under no circumstances be employed at the Chief Office after eight p.m. The practice of employing a certain number of female telegraphists from one till nine had long prevailed at the Post Office during two or three summer months, when most telegraph business was done. At the present time only twelve were so employed out of 600, and he did not think it would do any harm to the department.

Diploma of Electrical Engineer.—A Belgian Ministerial decree, dated 24th July, 1883, institutes a diploma of electrical engineer at the Liege University to be conferred:—1. On honorary and civil mining engineers of the Belgian section, who shall, after an additional year of special study, satisfy the conditions A of the programme; and 2. On mining or mechanical engineering pupils who, after two years

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of special study, shall satisfy the B and C conditions of the programme. Certificates may also be granted to the *ingénieurs des arts et manufactures*, and to mechanical engineers of the foreign section, who shall have successfully followed the course of the special year conformably with the programme (litt. A), to the exclusion of the mathematical theory of electricity.

METEOROLOGICAL STATIONS.—On Tuesday last in the House of Commons, Mr. Vivian asked the Secretary to the Treasury whether valuable scientific opinion had been received by the Meteorological Council adverse to their intended arrangement for reducing the number of the meteorological stations from seven to three; whether in the event of such a proposal being sanctioned by the Government, the vote would be reduced by the cost of the maintenance of the disestablished stations; and whether he would lay upon the table of the House copies of the communications which had taken place on the matter.—Mr. Courtney stated in answer that no final decision had yet been arrived at. It rested with the Meteorological Council, who could not decide until they reassembled in the autumn. If the stations were reduced the sum saved would probably be spent in the redistribution of the works.

ARMY AND NAVY HOTEL, WESTMINSTER.—This installation has just been completed by Messrs. Holmes and Vaudrey on account of the Liverpool Electric Supply Company, and was worked successfully throughout for the first time on Tuesday. It consists of 180 Swan high resistance lamps distributed through the reception rooms and hall, the large coffee room being brilliantly lit by 72 lamps suspended in the interior of four large crystal glass chandeliers. The whole of the circuits are controlled from a switch board in the hotel office. The dynamo and engine are placed in the basement within the building, a ten horse-power horizontal steam engine being used to drive a Schukhert Brush dynamo. The current is stored in 55 Faure-Sellon-Volckmar storage batteries, enabling the engine to be run during the whole of the day. Messrs. Woodhouse and Rawson are sub-contractors for the wiring.

THE ELECTRIC LIGHT IN EDINBURGH THEATRE ROYAL.—On the 2nd inst. a trial of the electric light was made for the first time in the Edinburgh Theatre Royal. The new system of lighting has been introduced by the Electric Manufacturing Company of Scotland, and the trial was made during the intervals in the burlesque of "Young Fra Diavolo," at present being played by the London Gaiety Company. The theatre is to be supplied with 200 incandescent lamps of 20 candle-power each, and of this number 150 were lighted last night. An engine-house has been erected in St. James'-street, on the opposite side of the street from the stage entrance to the theatre, and one of Sterne's gas engines, of about 26 horse-power indicated, at present supplies the motive power. Four of Dr. Higgs's dynamo machines, each giving light to 50 incandescent lamps, have also been fitted up; but when in full working order storage batteries, which have been constructed near the engine-house, can at any time supply light to 600 lamps of 50 candle-power each. The dynamo machines make 1,340 revolutions per minute, giving an E.M.F. of 50 volts. Each machine is self-regulating, and the engine is supplied with a gas regulator, which prevents any flickering of the lights.

THE STRIKE OF TELEGRAPHISTS IN AMERICA.—The telegraphists who still continue out on strike received on Monday last what is described as a severe check. It was expected that on that day the telegraphers employed on the railways would turn out and join those of the Western Union Telegraph Company, who had then been on strike for upwards of a fortnight. The railway men, however, refused to obey the order of the Telegraphers' Brotherhood, and are still at work. This event is believed to foreshadow their failure. The opinion is growing that the strike is virtually won by the company, and that it is only a question of time when the operators will return to work. Intelligence received on Wednesday, however, states that the telegraph operators on the railways controlled by Jay Gould and Garrett—we quote from the *Daily Telegraph*—actually carried out their threat at noon on Tuesday, and that this event bodes the final discomfiture of the companies. Later intelligence states that the number of railway telegraphers who left work on Tuesday was very few. During the last few days the wires near New York have been cut in many directions, a circumstance which, if correctly attributed to the men on strike, shows that they are growing desperate.

THE UNITED TELEPHONE COMPANY v. THE LONDON AND GLOBE TELEPHONE AND MAINTENANCE COMPANY.—This was an appeal before Lords Justices Cotton and Bowen by the defendant company from an injunction granted by Mr. Justice Pearson to restrain the defendant company from interfering with the telephone or telegraph wires, instruments, or apparatus belonging to the plaintiff company. The case, upon the application before Mr. Justice Pearson, was reported at the time, and as at the suggestion of the Court the injunction was discharged upon undertakings given by the parties, no decision was, at this stage of the action, given upon the rights asserted by the plaintiff and defendant companies respectively. It will be sufficient now to state that in the result the order for an injunction was discharged, both parties undertaking not intentionally to interfere with the wires, &c., of the other, with liberty to apply to the judge in chambers for directions in case any difficulty should arise in carrying new wires or maintaining the old wires without interference by the other company. The costs to be costs in the action. Mr. Hemming, Q.C., and Mr. Phipson Beale appeared for the defendant company, the appellants; Mr. Cozens Hardy, Q.C., and Mr. Moulton for the plaintiff company, the respondents.

ELECTRIC TRAMWAY AT BRIGHTON.—On Saturday last the electric railway formed on the beach opposite the Brighton Aquarium started work, and excited much interest, amongst those who visited it being the mayor. The railway is laid on wooden sleepers, placed on an embankment of shingle which has been thrown up and levelled just in front of the massive sea wall which was built to protect the Aquarium, the car being an ornamental one of wood, with seats for four or five persons on each side, and the electrical apparatus at one end, covered in a box. The motive power is supplied by a stationary "dynamo" at one end of the line, and the carriage travels smoothly and noiselessly. The track, which is about half a mile long, measures about two feet in width, and the return journey occupies four or five minutes, the average speed being about six miles an hour, notwithstanding the gradient, which is 1 in 125. On Bank Holiday the tramcar continued running from 9:55 a.m. to 9:0 o'clock in the evening, making about one hundred journeys, and carrying over twelve hundred passengers without a hitch. The average load is twelve persons, but this was often exceeded on Monday. The scheme has been carried out under the direction of Mr. Magnus Volk, electrical engineer to the Brighton Corporation.

THE EARTHQUAKE IN ISCHIA.—"No pen can describe," says the *Times*' correspondent, "the state of ruin to which

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this once lovely spot is reduced. The very topography of Casamicciola, with its surroundings covered with pretty villas and hotels, is absolutely obliterated. It is scarcely possible, even for one well acquainted with the place, to indicate the lines where the roads, the pleasant walks, the paths through the vineyards once ran. The ground is rent in long, deep fissures several inches in width. In one place only have I come on any trace of a pavement. That is a small portion of the main road leading upwards, where it skirts, cornice fashion, the side of the hill. The outer half has been swept away. Here and in other places there have been landslips, and large trees, carried half way down, are hanging horizontally from their sides, with telegraph wires still extended from them. Slight shocks continue to be felt almost daily, sometimes several in one day. It is noteworthy that the sismographic instruments on the Vesuvian Observatory indicated perturbations during the earthquake at Casamicciola, and also during the severe shock at Forio on Friday, while during the earthquake in 1881 they remained perfectly quiet. The activity of Vesuvius and the flow of lava almost ceased towards the end of last week. The telegraph service is being performed in huts which have been erected on the shore for the accommodation of various public officials.

The Postal Service in Country Districts.—The last postal report, says Mr. F. C. Loder-Symonds in a letter to *The Times*, shows a net revenue of £3,061,748 out of a gross revenue of £9,413,812. I live in a thickly-inhabited country district 60 miles from London. I cannot get a letter from London within the day or a newspaper until the day after publication. A large farmer observed to me the other day, "I don't take a daily paper, sir, for an old one is no good to me. I must go to market to see the paper." We are thus in a worse position than our predecessors of 50 years back, for the stage coaches then brought the mails from London in six hours. If I receive a telegram it costs me 7s. I cannot send one without travelling seven miles. A telegraphic service such as we see in the United States, in Switzerland, and in some other countries has still to be created. At present we have only telegraphic communication between towns. It is very doubtful whether the proposed introduction of sixpenny telegrams will hasten the creation of a fairly general system or will not rather retard such an extension and produce instead in towns such a flood of useless telegrams as to become a nuisance. In conclusion I respectfully submit that a public department which cannot carry a more efficient agency into country districts has no right to treat 32 per cent. of its gross revenue as fairly-earned profit. This large proportion of profit is only shown by curtailing the expenditure in the less remunerative districts below that necessary to provide a moderately efficient service. In other words, the department is, in this respect at least, worked rather as a source of general revenue than as a public service.

Electric Tramcars.—Negotiations have been going on between the French Electrical Power Storage Company and the General Omnibus Company in reference to the substitution of electricity for horse traction, and a practical experiment was made last Friday afternoon to test the efficacy of the system. One of the ordinary tramcars of the company, fitted up with the apparatus, was timed to start from the Place de la Concorde about five o'clock. The motive power is electricity, stored in Faure's accumulators. These are placed under the seats, which have to be raised for the purpose, and themselves weigh as much as two tons and a half. The car is lighted within and without by electric light. In order to mark the importance of the event, M. Cochéry, the Minister of Posts and Telegraphs, M. Ferdinand de Lesseps, M. Rouvier, and a number of engineers attended and took their seats in the vehicle. The first run was a few hundred yards up the Avenue des Champs Elysées, when the car was turned round (it can be guided everywhere with extraordinary ease), and taken back again into the Place de la Concorde. At one time a stoppage had to be made to allow a number of the occupants to dismount, since the weight of the accumulators and of the passengers combined was found to be too much for the springs. This, of course, will be provided for when special vehicles are built. The car was then run on to the tram-lines that pass through the Place de la Concorde, and went at a quick pace along the Quai de la Conférence in the direction of the Trocadèro. Even along this slight incline the speed could not have been less than eleven miles an hour. At the Place de l'Alma another turn was made, and the car taken quickly back to the Pont Royal. In every way the experiment is said to have been a success. It is at present proposed to run the electric tramcars to Versailles, and a contract to this effect is on the point of being signed.

A Tax on Brains.—Under this heading Mr. Athol Maudslay writes to a contemporary pointing out the excessive charges for patents in this country. He says:—"High fees for obtaining a patent not only discourage invention, but a high charge for patenting appears as though inventing were an offence punishable with a fine. The stamp duties and fees on and in connection with letters patent are as follow:—On application with provisional specification:—Stamp on petition for letters patent, £5; to be paid on giving notice to proceed, £5; to be paid on applying for warrent and patent, £10; stamp on final specification, £5—total cost of patent for three years, £25. On application with complete specification:—Stamp on petition for letters patent, £5; stamp on complete specification, £5; to be paid on giving notice to proceed, £5; to be paid on applying for warrant and patent, £10—£25. Subsequent payments to continue the patent in force:—Stamp on patent before expiration of third year, £50; stamp on patent before the expiration of seventh year, £100—total cost of patent for 14 years, £175. And as most inventors are forced to employ an agent, there are the agent's charges to be paid in addition to the Government fees and stamp duties. The agent's charges on a 14 years' patent would amount from about £10 to £15; that is supposing you made your own drawings, and drawings have to be lodged at the Patent Office in every case where a specification does not sufficiently describe the invention. So, in addition to the Government fees of £175, you have the agent's charges, the cost of models, experiments, drawings, working, advertising, and otherwise making known your invention, so that when a man intends taking out a patent, to make it worth his while to do so his invention must be worth quite £200 to leave him the smallest margin of profit. Under these circumstances, and with these oppressive and discouraraging charges, it is wonderful to think that any one should be daring enough to become a patentee."

The Railway and Electric Appliances Company.—In the Court of Appeal last Monday this case came on for hearing. The Duke of Manchester and others appealed from the order of Vice Chancellor Bacon, dismissing the petition to wind up this company. The company was incorporated in March, 1882, to take over certain patents and property belonging to the Williams Railway Patents Company and the National Electric Company. The petition was presented by the Duke of Manchester and other directors of the Electric Appliances Company, who allege that Mr. William Alexander Smith, a director of the Williams Company, and

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a promoter of the Appliances Company, had, as they were informed and believed, acted fraudulently in the matter of the purchase, and had, with two other persons, made secret profit out of the transaction. The promoters of the Appliances Company issued a prospectus and up to date seventy-two actions by persons representing about 42,000 shares had been commenced for the removal of their names from the register of shareholders on the ground of misrepresentation in the prospectus, and the concealment of secret profits paid to Mr. W. A. Smith and others; and the Appliances Company had commenced actions against both the selling companies. The petition alleged that the company could not be carried on profitably. The Vice-Chancellor, holding that the petition was wild and unreasonable, and that the petitioners desired to form a new company on the ruins of the old, dismissed the petition with costs. Hence the appeal. Mr. Horace Davey, Q.C., Mr. Millar, Q.C., and Mr. Carson were for the petition, which was supported by Mr. W. S. Owen for the company, and was opposed by Sir Hardinge Giffard, Q.C., Mr. Hemming, Q.C., Mr. Marten, Q.C., Mr. Northmore Lawrence, Mr. Buckley, Mr. Maidlow, Mr. Sturges, and Mr. Israel Davis representing various interests. Their lordships confirmed the decision of the Court below without calling on counsel for the respondents, and dismissed the appeal with costs.

Earthquakes.—Mr. H. P. Malet writes as follows, under date Homburg, August 1, with reference to the causes of earthquakes:—"On Monday last occurred one of the most destructive earthquakes of late years on the coast of Italy. Casamicciola is in ruins, 2,000 or 3,000 people are killed, and some other towns in the Island of Ischia have suffered This earthquake was called by Professor Palmieri a subsidence. Many years ago the *Geological Magazine* published a paper by me pointing out that earthquakes in general are caused by subsidence, that water is always at work sapping the earth beneath our feet, that where a subsidence from this cause has once happened the locality is liable to it again. That in volcanic regions there are two forces engaged in the undermining work—water and fire, therefore the subsidence is more certain. As a rule people seem still to think that the cause of volcanoes and earthquakes exists in the ideal heat of the centre earth, but there is no proof whatever that there is now or ever was any inherent heat or fire in the solid body of this world. The old idea that combustible materials existed in the deposits of the earth which only required exposing to the action of water to make it incandescent and eruptive has been pretty clearly demonstrated to be the true cause of volcanic energy. As earthquakes often occur immediately before eruptions, it is clear that the igneous or combustible material is set free by this movement, with the greater or smaller consequences. If the eruption was caused by any general heat in the interior, as some suppose, or from local lava lakes, as others think, there would be no reason why the volcanic energy should be as fickle as it is, or why volcanoes should be quite burnt out. The earthquake, the incandescent material, and water explain these points. Science has lately given up the idea of a fire earth; it may as well give up the theory of earthquakes having any other cause than the natural gravitation of the surface into the hollow places prepared for it by the certain sapping of fire and water."

The Electric Lighting of the Strand.—This provisional order came on for third reading on the 2nd inst., in the House of Commons, when Mr. Sheridan moved that the Bill be recommitted. The hon. member said that a great deal of haste had been shown in connection with the progress of this Bill. The hybrid committee who examined it only reported on Tuesday, and their report had only yet reached members through the medium of the press. Yesterday, however, it was considered, and now it was proposed to read it a third time. This amendment raised a most important question. The Strand District Board had entered into a seven years' contract with the Jablochkoff Company for the supply of the electric light, but the Board of Trade had set that aside, and had granted a provisional order to the Edison-Swan Company which amounted virtually to a monopoly for 21 years. In his opinion, this preference of the Board of Trade required some explanation, and if there was any prejudice of this sort on the part of the permanent officials it was right that the House should inquire into the nature, extent, and character of that prejudice. He was informed that two of the permanent officials sat on the committee and influenced it in favour of their view. If this Bill were passed, the House would be conferring a boundless authority upon the Board of Trade, and a power of preventing local authorities from entering into any contract for the lighting of their thoroughfares. —Mr. W. Holms observed that this Bill had been sent to a hybrid committee in order that every side should be heard, and after a most careful examination they had no hesitation in deciding as to what decision to arrive at. The Board of Trade had no preferences or prejudices, their only object being to secure the best terms for the public. They had been especially careful not to give any monopoly whatever to any company, because if during the 21 years during which the order was in force the company failed to supply as good and cheap a light as other companies, the Board had the power to grant another order over the same area.—Mr. Sheridan's amendment was rejected without a division.

The Provisional Orders Electric Lighting Bills.—On these Bills, nine in number, coming on for second reading in the House of Lords, they were opposed by Viscount Bury, Lord Salisbury, and several other peers. Viscount Bury said he thought that the Government would have made a statement on the subject, but as they had not done so he would make a few observations. He had nothing to do with any of the electric lighting companies whatever, and therefore what he said was on public grounds. This Bill was one of 500 pages, filled with the most abstruse technical matters. Most of these Bills (nine in number) were not opposed, but they should, notwithstanding, be thoroughly examined, as all other Bills were. A year ago there was a great mania for electric lighting, and in the Session of 1882 a Bill was passed enabling the Board of Trade to make provisional orders. The Bills on the table dealt with districts, each of which was very little less than a square mile. It was a serious question whether that plan should not be abandoned. As a matter of fact, he contended that these Bills would be great monopolies, and therefore the expense of such lighting should be estimated and stated; also, there should be ascertained the expenses of the works, and whether the companies would be able to carry them out. He understood that for these Bills £50 each had been paid to the Board of Trade. One company, which had paid £230,000 for patents, which were not now worth anything, was down in one Bill for 25 districts in the city of London, and if each was an area of a square mile, the company would be committed to an expenditure of £2,500,000, and had only paid £50 for the concession. This company, and others like it, would not go on with their concessions, but would sell them piecemeal to other parties, and would probably make a profit. It was a serious question whether Parliament should allow this to be done. If the concessions were not sold the company might fall to the

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ground, though the public might want electric lights. He contended that these enormous Bills should not be brought in, but that there should be one general Bill—as in the case of the Railways Clauses Consolidation Act and others. Then there should be clauses as to the price to be charged, as he found it differed in these Bills. The noble lord then compared the prices charged for gas per 1,000 feet and for electric lighting per unit, and said that while gas would be 3s. 2d. per 1,000 feet, the electric lighting would be equivalent to 5s. 10d. to 7s. 6d. per unit; therefore this was a matter which should be closely investigated, and he contended that the price would be very much higher than for gas—candle for candle. He thought that these Bills should not be proceeded with at present. After some discussion, however, the Bills were advanced a stage.

South Wales Institute of Engineers.—At the meeting of this institute, held at the end of July, one or two papers on electrical subjects were read by Mr. S. F. Walker. Speaking of accumulators, he said "if the action of the battery were perfect there should be no consumption of materials within the cells. The only consumption that should go on would be in the coal under the boilers supplying the steam engine that drives the dynamo. Leaving out the loss that occurs in the furnace itself, the following items of loss of power must be considered and allowed for. The most perfect dynamo only converts 90 per cent. of the mechanical energy of the engine into electricity, so that 10 per cent. is lost here. Opinions differ as to how much of the electrical energy furnished by the dynamo to the accumulator is restored as electrical energy in the external circuit, some holding that 80 per cent. is restored and others that only 50 per cent. is yielded. Then there must be a further loss of probably 10 per cent. in converting the electric current furnished by the accumulator into light or mechanical force; so that the utmost return, with the best dynamo and under the most favourable circumstances, would be under 60 per cent. But several other considerations, chiefly chemical, occur to subtract further from this efficiency. The Faure and the Faure-Sellon-Volckmar batteries have been used to propel a boat on the Thames; a tramcar has been driven with cells under the seats and the dynamo underneath the vehicle; 200 Lane-Fox lamps were kept alight at the Crystal Palace while the first electrical exhibition lasted; that the Pullman train on the Brighton Railway was lighted by them; that Professor Ayrton has ridden a tricycle through the City driven by a motor worked by accumulators. As for the future, we may hope to see much greater results. Our rivers and waters may be navigated by electrically-driven launches; our cyclists may cover miles of country with no exertion whatever on their part save that of steering; and underground trains will be driven either by compressed air or electricity to the increased comfort of the passengers. In ordinary industrial life the secondary battery, if it can be made cheap and reliable, will be of immense service in a great variety of ways, the initial steam power being in many cases taken from the margin of power which most large engines in factories now have over and above the maximum requirements. Leaving a proper margin of safety for unforeseen contingencies, and still working the engine well within its power, it would be quite possible to utilise the margin of variation to charge secondary batteries, which in turn would furnish light, motive power, or even assist to drive the engine which charged it." The discussion on these papers, which was adjourned, showed clearly the dense ignorance that exists upon electrical matters. It was asked whether dynamo machines could not be immersed in water, and so worked safely as regards sparking for mining purposes, and when it was answered that short circuiting would take place, the further question was asked, whether this would not be avoided by insulating the tank?

Underground Wires.—Mr. W. C. Behrens, secretary to the General Committee on Underground Communication, forwards a circular letter, given below, and asks for plans to be submitted for examination to 115, Broadway, Room 47, New York:—"It is required that the conductors or wires of the telephone system, of the several different systems of telegraphic communication, and of the several systems of arc and incandescent electric lighting (systems greatly varying in electromotive force used, and in character and strength of current) be laid in a single conduit or way, and —what is absolutely essential—in a manner so as to be inductively independent of each other and practically free from retardation. As an example of the necessity of securing freedom from induction and retardation, the telephone may be cited. Being extremely sensitive, it responds to electrical impulses of many thousands in a second, and it is essential that no substantial modification of the electrical impulses shall take place during transmission. As induction varies inversely as the square of the distance, it is evident that the necessary proximity of a large number of telephone, telegraph, and electric light wires in a single underground conduit would very greatly increase the existing annoying interference from induction, not only from the telegraph and electric light wires, but from other telephone wires. With any considerable length of wire comes retardation due to increased electrical capacity, and, as is well known, an enormous increase of capacity results when an insulated wire is placed underground. Retardation not only delays but modifies and distorts the signals. The sound produced by the voice must be preserved amid great rapidity of change, and when retardation is so great that signals cannot be transmitted with this necessary rapidity, then said sounds are so imperfectly reproduced as to become partially or wholly unintelligible. The Holmes Burglar Alarm Telegraph, central office system, is based upon the use of a continous current of constant quantity and intensity, in connection with a delicately constructed galvanometer. Any deflection of its needle, caused by induction destroying the constancy or changing the intensity of the current, gives a false alarm, and this induction destroys the entire system. The character of the service of the Time Telegraph Company, at present employing a metallic circuit, exacts perfectness of operation, and is such that occasional failure of working, except at very long intervals, would be fatal to its usefulness and its existence. In consequence, freedom from breakage, leakage, heavy induction, defects in insulation, and ground connection is absolutely essential. The particular requirement of the District Telegraphs (messenger service) is facility for making connection with every house without disturbing the pavement. Metallic circuits are employed of a length not exceeding one or two miles. These will serve as illustrations. The conduit or electric way must be of large capacity —say from 2,000 to 5,000 wires—and of a practicable form and size in cross-section. If naked wires are employed moisture must be excluded from them and from all connections. If insulated wires are used the character of the insulation will determine the necessity of exclusion of moisture. The details of construction must be such as to permit, without removal of the pavement, immediate connection, or repeated changes with every house or building for all kinds of electrical service, access for repairs and testing, and the laying of additional wires and their removal."

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CURRENT ENERGY.—VI.

BY OLIVER HEAVISIDE.

(CONTINUED FROM PAGE 248.)

But although, because W = EQ is true for convection of electricity, it is not therefore immediately seen to be self-evidently true in the case of a conduction current; yet it is found to be necessary when we apply the principle of conservation of energy, according to which the disappearance of an amount of electrostatic energy must always be accompanied by the appearance of an equal amount in other forms of energy. Let there be a distribution of static electricity, the separate charges being kept insulated and unalterable. We know, in the first place, that if we alter the distribution in any manner by convection of the charges the mechanical work required to effect the change of configuration is equal to the increase produced in the quantity $V = \frac{1}{2}\Sigma P\rho$, where ρ is an elementary charge and P its potential, depending on its position with respect to the other charges. The increase produced in V equals the sum of force × distance moved for all the charges ; or, in terms of the charges, the sum of electric force × electricity × distance, where the product of the first two factors is mechanical force, and of the first and third electromotive force, or difference of potential; the E.M.F. per unit distance being the electric force, otherwise called the E.M.F. at a point. Of course ordinary force acts on matter, and electric force on electricity. The quantity V, in any state of the system, is the whole work required to set up that state by bringing the elementary charges to their places from an infinitely widely separated state. But (and this view of the matter is instructive in regard to discharge by cancelling of opposite charges), it is also the whole amount of work spent in separating the positive half of the electricity from the negative half, supposing the electricity given initially in a state where we have every elementary positive charge paired with an equal negative charge infinitely near it, a state equivalent to no electrification. And, conversely, V is the work done by electrostatic force on the electricity when we reverse the above processes, and either separate the charges infinitely, or let them come together and co-exist in pairs of opposite kinds. To illustrate the latter case, let there be two conductors, A with a p sitive charge Q, B with an equal negative charge, every e ementary portion of A's charge being connected with a corresponding negative charge on B by a tube of displacement. Let A be a hollow shell with a trap door; bring B up to A. By this V is reduced, the force being an attraction. (The value of V is simply $\frac{1}{2}$ EQ, where E is the difference of potential of the two conductors.) Open the door, put B inside, and shut the door. During the passage of B through the door most of the electricity on A moved from the external to the internal surface of the shell, and when the door is shut again it is all on the internal surface. Now let B expand and take the same form as the inner surface of A, and be separated therefrom by a thin layer of dielectric. Their difference of potential now, and in any further expansion of B, will be simply proportional to the thickness of the layer (as for two parallel plates with equal opposite charges insulated), and hence becomes indefinitely small as B approaches A, and the value of V becomes infinitesimal. Here V has disappeared by mere convection of the charges, a quantity, V, of mechanical work has been done, and V is strictly the potential energy of the state of electrification.

But if, as in Maxwell's development of Faraday's views, we regard a state of electrification to be accompanied by an elastically strained state of the dielectric medium, the potential energy of the strain being V, it becomes more easily comprehended how, since when a strained elastic body is allowed to return to a state of no strain it gives back the work done in straining it, which amount of energy may be convertible into various forms, if we in *any* way cause the electrical phenomenon to disappear, there will be a transfer of an amount V of energy from electrostatic into other forms, whose kind will depend on the circumstances of the disappearance. The appropriate form for V on this view is $\Sigma KR^2/8\pi$ (identically equal to the former expression in terms of the charges and potentials), R being the electric force and K the specific inductive capacity of the medium, throughout which the summation extends. This is with the ordinary electrostatic units, but if we choose them so that $e/4\pi r^2$ is the electric force at distance r from a charge e in air, we shall find $V = \Sigma KR^2/2$. Here R is the force, and KR the displacement it produces, so that the energy per unit volume = $\frac{1}{2}$ force × displacement, the force and displacement being both electrical, the case being exactly analogous to that of a real force producing a displacement of matter, the work done during the displacement being the displacement × mean value of the force, *i.e.*, when the displacement is proportional to the force, $\frac{1}{2}$ force × displacement.

The potential energy of a state of electrification may, according to the circumstances of the discharge, be used up as mechanical work, setting bodies in motion with consequent kinetic energy of visible motion or of heat of friction, &c., or as heat through the medium of the kinetic energy of conduction currents, or as the energies of sound, light, magnetisation, &c., the number of possible transformations through the agency of conduction currents being very considerable. In passing to conduction currents we may notice the anomalous character of a fact connected with one kind of discharge. A dielectric, as air, is unable to bear tension above a certain amount. The tension along lines of force is measured by the same quantity, $KR^2/8\pi$, as before, the tension per unit area being numerically equal to the energy per unit volume. Above the limiting tension we have disruptive discharge, varying from the tiny spark to the magnificent lightning flash that so terrifies the vulgar and charms a Faraday, a break down of the dielectric, accompanied or followed by light, heat, sound, violent commotion of particles, and other effects. Now, Sir W. Thomson found that a greater tension was required to produce a spark between two close parallel plates (one having very slight curvature to localise the discharge) at small than at greater distances, an extraordinary result, if true generally and not depending on some unobserved special peculiarity in the experiments. We have this for a consequence, that two electrified bodies, the tension between which is insufficient to effect disruption, may be discharged by increasing the distance between them. This will obviously be so if the tension be nearly sufficient to effect disruption at the smaller distance, and if in moving to the greater distance the tension remains the same as before, hence becoming sufficient for discharge at the greater distance. And the constancy of tension is attained in the case of two parallel plates equally and oppositely charged by a battery to any desired difference of potential. On removing the battery, and so keeping the charges constant, and increasing the distance between the plates, the work done in separating them to, say, n times the original distance just multiplies the energy n times, and the force and tension remain of constant amount, save near the edges, so long as the distance is a small fraction of the diameter of the plates.

Now, let our system of electrification be merely a charged condenser, and connect its terminals by a conducting wire. The charge rapidly disappears, the rate of disappearance being the measure of the electric current, expressed symbolically by $Q = Ct$ for any time t sufficiently small that the current C may be considered constant, Q being the quantity of electricity that has disappeared in that time. The current at any moment is proportional to the E.M.F. at the moment which (disregarding correction for electro-magnetic induction) equals the difference of potential of the condenser, and hence is proportional at any moment to the charge left. Thus, as time increases arithmetically, the charge left and the current fall geometrically. We have $C = -c\dot{E}$ where C is the current, c the capacity of the condenser, and E the difference of potential at time t. Also, by Ohm's law, $E = rC$, if r be the resistance of the wire. Hence $C = -rc\dot{C}$, integrating which we find $rC = E_0 e^{-t/rc}$, which gives us the current at any time t after the commencement of the discharge, E_0 being the initial difference of potential. The time taken in falling from the initial full strength of current to any stated fraction thereof is proportional to rc, which is an interval of time, called by Lord Rayleigh the time of subsidence, really the time required to fall from 1 to e^{-1}, or from 1 to 1/2·7.

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Let the condenser be made larger and larger, thus increasing the time of subsidence, and imagine it to become, for the purposes of argument, enormously large, thus containing, with the same difference of potential, an immense store of electricity and energy. The time of subsidence becomes so great that we shall have, on joining the terminals through a wire, a practically steady current with constant E.M.F. In any time t (small compared with the time of subsidence) we have $Q = Ct$, where Q is the charge that has left in that time, and C the current; also $E = RC$; and finally $W = EQ$ is the work done by E in driving Q, or, in other words, it is the amount by which the potential energy stored in the condenser falls in the time. By conservation, W is the amount of energy to be accounted for.

Now, in the above, we have been really dealing with the disappearance of static electricity, and so know that $W = EQ$ must be true. But if, instead of discharging our big condenser through a conductor and setting free electrostatic energy, we substitute a galvanic cell for the condenser, we find exactly the same phenomena produced as before. There is mechanical action between the wire and a magnet, between different parts of the wire, power of magnetising iron, of effecting electrolysis, &c., in both cases, and in both cases are the actions steady. Now here, although with the galvanic cell we have no disappearance of static electricity, or, indeed, any sign of a large store of it to be drawn upon, yet the phenomena, as regards the conductor being the same, must be virtually equivalent to the discharge of static electricity, and we may apply the same formulæ exactly as in the case of the condenser, $Q = Ct$ and $W = EQ$, which are now truths, though not truisms. The Q is now not electricity *in esse*, but *in posse* (*i.e.*, without hypothesis to account for the absence of electric force from the electricity we may assume to be moving). To verify which, we may insert our big condenser in the circuit, when the phenomena in the wire will be as before, whilst in the time t the condenser will acquire a charge of amount Ct. It will, however, have very little energy compared with EQ, the whole work done whilst it was being charged. And now we may, of course, discharge this Ct of electricity, removing the cell first, through a wire, when it will be entirely done for.

Returning to the cell with steady current and no condenser in circuit, we may measure the E.M.F. maintaining the current in the wire electrostatically, by means of an electrometer connected to its ends, and its strength is RC, where R is the resistance of the external wire. RC is not the whole E.M.F., for the battery has itself the same power of limiting the current as the wire, which is proved by the observed difference of potential rising when the length of the external wire is increased. The limit to which it tends is the complete E.M.F.

But the cell will show the same difference of potential when the circuit is not closed conductively at all. According to Maxwell's theory there has been still a current in a closed circuit, viz., as before in the same direction through the cell, and then from one terminal to the other through the air, the current of "displacement" in the air, however, having the remarkable difference (amongst others) from that in a conductor that the displacement is elastically resisted, and hence will return when it is allowed to, whereas there is no such reversibility in a conduction current. The case is, of course, substantially the same as in charging a condenser, the difference being in the amount of capacity and the quantity of electricity concerned, which are excessively small when the terminals have no large opposed surfaces connected to them. And the same thing occurs with the circuit closed conductively, there being also other circuits through the air on starting the current, which results in charging the wire. Nor is this latter a mere secondary affair, for without the static charge there would be no E.M.F. in the wire. It is therefore of primary importance for maintaining the current.

The observed difference of potential of the disconnected cell should not be confounded with its E.M.F. They are numerically equal, but opposed in direction, as regards their power of producing current in the circuit, viz., cell and air. That this is so is evident on considering that if there were no E.M.F. to keep up the static charges they would unite through the cell itself. It is the same when we have, not an ordinary galvanic cell, but merely two metals A and B in contact in air, forming a circuit A, air, B, A. If we find B at a higher potential than A, the E.M.F. that caused it must have been numerically equal to their difference of potential, and have acted in the direction B, air, A, B, with a transfer of electricity in this direction round the circuit, lasting until the difference of potential stops further current. It is no easy matter, however, to settle exactly where the small consumption of energy needed for this state of electrostatic energy comes from, though probably it arises merely from a very minute amount of chemical action.

Since EQ of work is done by E during the passage of Q, an amount EC is done per second. The supply of energy obviously comes from the galvanic cell, of which more later, whilst we now consider its destination. In $W = EQ$ insert RC for E and Ct for Q, their equivalents when the circuit is conductively closed, and we obtain $W = RC^2t$ in terms of resistance and current, as the amount of energy to be accounted for. The solution is supplied by Joule's discovery that with a steady current in a conductor heat is continuously developed, its amount being proportional to the square of the current and to the time it has been on. Hence, if H be the heat, expressed as energy to avoid the useless introduction of Joule's co-efficient, we have $H = R_1C^2t$, where R_1 is a necessary quantity required to make R_1C^2t energy. Now RC^2t is energy, being the same as EQ, consequently R_1 is resistance, and can therefore be only R multiplied by a mere numeric. But if no other work is done than in heating the wire, we must have $H = W$, the numeric $= 1$, and $R_1 = R$. Hence $H = RC^2t$ expresses Joule's law.

Thus, in $EC = RC^2$, which is the equation of activity, or rate of working in a galvanic circuit, when the sole result is heat in the conductor, we may say that EC is the work done by E in driving C, (true, whatever other effects than heat may be produced) and RC^2 the equivalent rate of generation of heat. We may here advantageously reintroduce the mechanical analogy before employed, viz., a body set in motion by a constant force F, and opposed by a resisting force rv, simply proportional to its velocity, v. So long as F is greater than rv there is acceleration of velocity, which must cease when $F = rv$, which equation consequently gives us the steady velocity. At the same time Fv is the activity of the applied force F, its rate of working. Now, if the resisting force rv be frictional, the equivalent of Fvt is found to be heat. Thus $Fv = rv^2$ corresponds exactly to $EC = RC^2$ in the galvanic circuit, and, with the proper limitations, the expression sometimes used, the frictional generation of heat by the current, is perfectly appropriate. If we like, the body moved may be a fluid in a pipe, moving round and round, as some people think electricity moves.

The heat RC^2 per second is produced under all circumstances in conduction currents, being a necessary part of the phenomenon. Other work may be being done, but, with a given current, it will not affect the generation of heat in the least, which can only be altered by altering the current, unless we count the change in R produced by the heat itself raising the temperature, making R indirectly a function of C or of Q, but really a function of the temperature. But in a dielectric current there is no such development of heat, the energy being potential, and returnable. The only quite universal characteristic of current is probably its relation to magnetic force. The heat resulting from current in a conductor has done with electricity; it is diffused by heat conduction, a comparatively slow intermolecular process, by currents of air, or goes off by the wonderful process of radiation.

It will be interesting to observe the form taken by $EC = RC^2$ in a non-isotropic medium, in which the relations between E.M.F. and current are contained in three linear equations with nine co-efficients of resistance, and to note whether the rotational phenomenon has any peculiar influence upon its form. Using the notation on p. 198, and referring to the equations of resistance $X = r_{11}u + \ldots$, &c., we have, E being the E.M.F. with components X, Y, Z, and C the current with components u, v, w,

$$\overline{EC} = Xu + Yv + Zw$$
$$= r_{11}u^2 + r_{22}v^2 + r_{33}w^2 + (r_{12} + r_{21})uv + \ldots$$

Here we see that we are only concerned with the sums of the

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transverse co-efficients, not with their differences, on which the rotation depends. If no rotation, $r_{12} = r_{21}$, &c., and now, choosing the axes of reference to be the principal axes, we have

$$\overline{EC} = r_1 u^2 + r_2 v^2 + r_3 w^2,$$

where $r_1, \ldots$, are the principal resistances; which reduces to $EC = RC^2$ when the co-efficients are equal, and the medium isotropic with E parallel to C.

In the case considered later, isotropy plus rotation, we have $\overline{EC} = RC^2$, nearly as simple as with perfect isotropy. Dividing by C, we see that the component in the direction of the current of the actual E.M.F. is RC, as may be verified by the formulæ on p. 199. When, as, later, the transient effect has subsided, and the current goes straight under the influence of the ordinary E.M.F., which we may now call E_1, and the transverse E.M.F. of strength TC, their resultant being E the actual E.M.F., $\overline{EC} = RC^2$ becomes, by division by C, $E_1 = RC$, hence $E_1C = RC^2$, just as without the rotation.

REPORT ON THE EDISON-HOPKINSON DYNAMO

We give below a report by Mr. F. B. Sprague on the Edison-Hopkinson dynamo:—

I have to make the following partial report of the tests of the new dynamo-electric machine built by Mather and Platt, of Manchester.

Fig. 1 shows the general shape and dimensions of machine

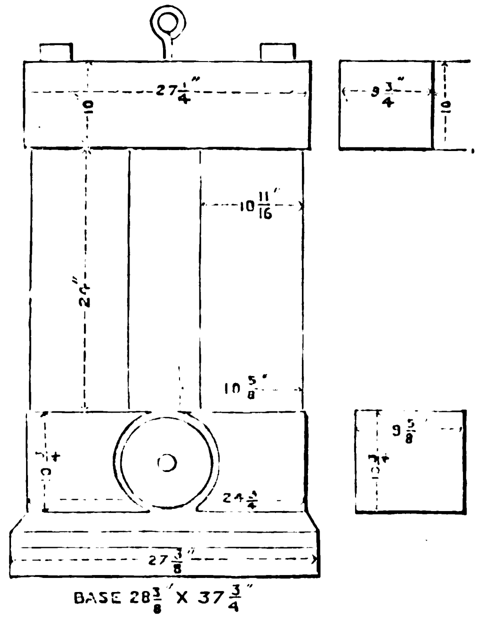

FIG. 1.

Additional dimensions and characteristic features of the dynamo are:—

General arrangements those of a shortened and differently proportioned Edison dynamo.

Pulley, however, is outside of bearing, and with a face of 6¾", and diameter of 10 1/16", projects 8¼" outside the base plate.

Field coils wound over a 9" core with 10 layers of No. 16 copper wire (B.W.G.). Two arms in series.

Armature, diameter of core 9", 74 coils, single turn, 8 strands of No. 16 wire, average length 43".

Wire bound. Diameter 10½" with 1/16" clearance from pole faces. Zinc plate connecting pole faces. Ends of magnets *not* scraped.

Resistances: Field cold 36·5 ohms.
Armature cold ·026 ohms.
Field measured, armature calculated.
Field warm 37· ohms.
Armature warm ·0325 ohms.

Power supplied from a Lawrence (Armington and Sims) engine, high speed, and non-condensing, driven by a link belt through an Alteneck tension belt dynamometer.

Engine diameter	......	8½"	accepted
Stroke	......	9 15/16"	measured
Piston rod	......	1 3/8"	„
Fly wheel	......	40"	„
Indicator spring	......	56"	

$$1 \text{ h.-p.} = \frac{2.\ \text{P. L. A. revs.}}{33{,}000}$$

$$= \frac{\dfrac{2.\ \text{P.}\ 9\frac{15}{16}}{12} \cdot \dfrac{\pi}{2}\left(2\cdot425^2 - \frac{11}{16}^2\right) \text{rev.}}{33{,}000}$$

$$= \text{Mean pressure} \times \text{rev.} \times \cdot0028107$$

The mean pressure is best found by taking area of cord with a planimeter, dividing by the length of cord, and multiplying by the spring. Engine not permanently secured but firm enough to drive well. Revolutions timed by reference to a continuous counted running motion from valve stem. Boiler pressure from 97 to 104lb.

Dynamometer, Alteneck pattern, designed to measure difference of tension of two parts of belt.

A. Driving pulley.

B. Driven pulley.

C. C. Pulleys with faces close together, and gripping the two parts of the belt. The lower is the driving part, and the resultant pull is downwards, which pull is opposed by an upward external and measurable pull, which keeps the dynamometer in a central position.

The following were the dimensions:—

Diam. A. 40"
„ B. 10 1/16"
„ C. 9 5/16"
Distance apart of centres of C C 11½".
Thickness of belt 9/16".
Resistance A E 117".
„ B E 26¼".

To find constant we have the following:—

T Tension on lower belt.
T^1 „ „ upper „
2 r and p diams. of small pulleys B and C.
2 R „ „ large pulley A.
κ Thickness of belt.
α and β half enclosed angles on each side.
d Distance from E to centre of B.
D „ „ „ „ A.
e „ apart of centres of C C.

Then net. spring = dif. of pulls = $(T - T^1)(\sin\alpha + \sin\beta)$.

$$\text{Sin}\,\alpha = \frac{r - \frac{1}{2}(e - p - 2\kappa)}{d} = \frac{r - \frac{e}{2} + \frac{p}{2} + \kappa.}{d}$$

$$\text{Sin}\,\beta = \frac{R - \frac{e}{2} + \frac{p}{2} +}{D}$$

$r = 5\frac{1}{32}''$ $\qquad d = 26\frac{1}{4}''$
$e = 11\frac{1}{2}''$ $\qquad D = 117''$
$p = 9\frac{5}{16}''$ $\qquad R = 20''$
$\kappa = \frac{9}{16}''$

Then $\sin\alpha =$ ·17143
$\sin\beta =$ ·16640
$\text{Sin}\,\alpha + \sin\beta =$ ·33783

$$T - T^1 = \frac{\text{spring}}{\cdot33783} = 2\cdot96 \text{ spring.}$$

$$\text{H.P.} = \frac{\text{speed} \times (T - T^1)}{33000}$$

$$= \frac{\text{rev. of B} \times \pi \times \dfrac{10\frac{1}{16}}{12} \times \dfrac{\text{spring}}{\cdot33783}}{33000}$$

$$= \cdot0002363 \times \text{rev.} \times \text{spring.}$$

That is, the horse-power transmitted is the product of the

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increased tension on supporting spring, the revolution of the dynamo, and the constant factor ·0002363.

To prevent violent vibration and to facilitate readings there were used three springs and a dash pot. The ranges of springs were 60, 100, and 180lb., two being direct, and one circular. These were supported by bridle arms, and were raised or lowered by tackle. The connection between lower bridle and dynamometer frame was by rubber band. The dash pot was a cylinder full of oil, in which moved an iron pulley, wrapped with Manila rope.

The play of the dynamometer did not exceed $\frac{1}{32}$″.

It was first balanced at rest, then free, and finally with load.

Instruments for measuring potential and current were of of the "Thomson" design, the current in the lamp circuit and the potential at the brushes being taken.

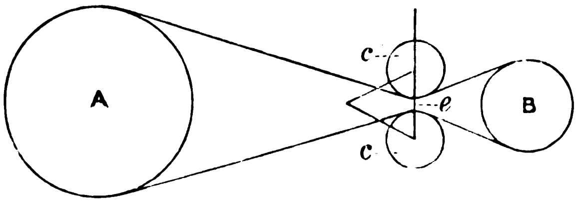

Fig. 2.

The magnets were tested by the Poggendorff method, as in Fig. 5.

$$\text{Total H. magnetic field} = G\,r \times \frac{\text{Position}}{E \times \text{Resist.} \times \text{Dif.}}$$

E = 1·457 Clarke's Standard.
Gr. = 6428.

Mean force in laboratory, Westminster.

	Earth	No. 45	No. 17
May 7,	·121	9·41	11·40
„ 8,	·122	9·46	11·45
„ 12,	122	9·40	11·52

Total H. field for Manchester.

E and No. 45	9·55
E and No. 17	11·61

Characteristic curve, Fig. 6.

This was found by taking the potential at the brushes, the field magnets being excited by a separate machine. The only current passing through the armature was that in the high resistance galvanometer and leakage, a ground of unknown resistance. This curve is designated A.

Another curve, B, is added. This gives the electrical energy expressed in horse-power expended in the field of 37 ohms.

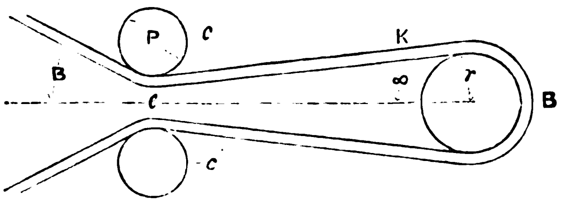

Fig. 3.

In A, vertical distance, or ordinates, are volts and abscissæ current in amperes.

In B, ordinates represent horse-power, while abscissæ are the same as in A.

The results of three fairly full loads are given.

No. 6.

Time.—About one hour.

Load.—192 lamps and ground of about 5 amperes. Lamps not up to candle-power.

Potential galvanometer:—

Magnet	No. 45
Position	2
Strength	9·55
Average deflection	20·79
Potential at brushes	99·27 volts.

Current galvanometer:—

Magnet	No. 17
Position	2
Strength	11·61
Average deflection	19·39
Current in lamp circuit	112·56 ampere.
„ field	2·68 „
„ armature	115·24 „
Resistance lamp circuit	·882 ohms.
and field	·861 „
Total resistance of circuit	·8935 „
E.M.F. = 102·97 volts.	
Electrical energy in lamp circuit	14·97 h.-p.
„ „ field	·36 „
„ „ armature	·58 „
Total	15·91 h.-p.

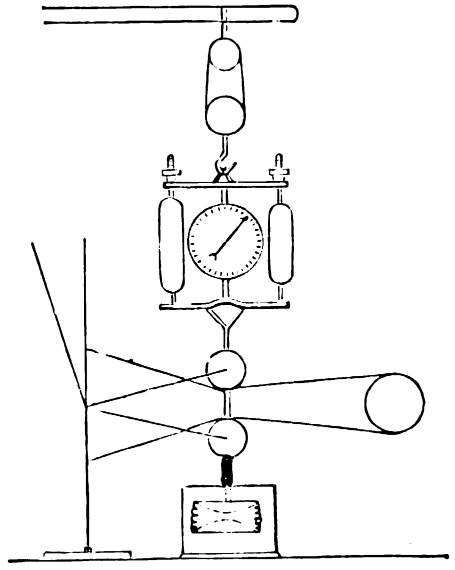

Fig. 4.

Dynamometer spring:—

At rest	112·23lb.
Running free	115·00lb.
Load	180·11lb.
Total dif.	67·88lb.
Above friction	65·11lb.
Total power to armature	17·34
Power above friction	16·63
Friction	·71
Dynamo speed	10·81
Engine „	289·3
Efficiency of conversion	95·7 per cent.
Commercial efficiency	86·3 „

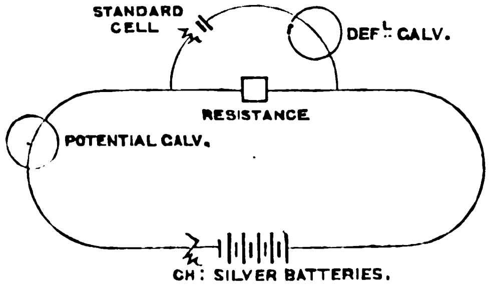

Fig. 5.

Dynamo behaved well. Fields cold. Armature moderately warm. Wrist not uncomfortable on coils. Can also be held on commutator. Little sparking. Some lateral play of armature and spindle. Bearings cool. No increased heating after standing.

No. 8.

Time.—31 minutes.

Load.—192 lamps and ground of about 5 amperes =, say, 199 lamps.

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BRIEF OF THREE EXPERIMENTS.

No.	Time.	Speed. Engine.	Speed. Dynamo.	Current in amperes. Field.	Current in amperes. Lamp circuit.	Current in amperes. Total.	E.M.F. in volts. Brushes.	E.M.F. in volts. Total.	Elec. H.-P. appearing. Field.	Elec. H.-P. appearing. Armature.	Elec. H.-P. appearing. Lamp circuit.	Elec. H.-P. appearing. Total.	H.-P. delivered to battery. Absorbed.	H.-P. delivered to battery. Total.	Efficiency. Conversion.	Efficiency. Commercial.
6	1hr.	289	1081	2·68	112·56	115·24	99·3	103	·36	·58	14·97	15·91	16·63	17·34	95·7	86
8	31min.	309	1157	2·92	123·07	125·99	108·0	112·1	·42	·69	17·81	18·92	20·12	20·88	94·0	85
9	1hr. 1min.	315½	1179	2·95	144·6	147·55	109·3	114·1	·43	·95	21·18	22·56	23·79	24·56	94·8	86

Means 94·8 per cent., 86 per cent.

To E. H. Johnson, Esq., Royal Hotel. (Signed) FRANK J. SPRAGUE, London, May 17, 1883.

Potential galvanometer:—
Magnet .... No. 45
Position 2
Strength .... 9·55
Average deflection .... 22·62
Potential at brushes .... 108·01 volts.
Current galvanometer:—
Magnet .... No. 17
Position 2
Strength .... 11·61
Average deflection .... 21·2
Current in lamp circuit .... 123·07 amperes.
„ „ field .... 2·92 „
„ „ armature .... 125·99 „
Resistance lamp circuit .... ·877 ohms.
and field .... ·857 „
Total resist. of circuit .... ·8895 „
E.M.F. .... 112·09
Electrical energy in lamp circuit .... 17·81 h.-p.
„ „ „ field .... ·42 „
„ „ „ armature .... ·69 „

Total .... 18·92 h.-p.
Dynamometer spring:—
At rest .... 112·23lb.
Running free .... 115·00lb.
Load .... 188·61lb.
Total difference .... 76·38lb.
Above friction .... 83·61lb.
Total power to armature .... 20·88 h.-p.
Power above friction .... 20·12 „

Friction .... ·76 h.-p.
Dynamo speed 1157
Engine „ 309
Efficiency of conversion .... 94·0 per cent.
Commercial efficiency .... 85·3 „
9·5 lamps per total h.-p.
9·9 „ „ absorbed h.-p.
10·6 „ „ h.-p. electrical energy
11·2 „ „ h.-p. of „ „ in ex. cir.

REMARKS.—Lamps not being close to machine, they were probably not quite up to candle-power, although all in the room seemed well up. Similar remarks about behaviour of dynamo as were made in experiment No. 6. There was no apparent increase in heating.

No. 9. Time.—1 hour and 1 minute. Load.—230 lamps and ground of about 5 amperes, say 237 lamps.

Potential galvanometer:—
Magnet .... No. 45
Position 2
Strength .... 9·55
Average deflection .... 22·89
Potential at brushes .... 109·3 volts.
Current galvanometer:—
Magnet .... No. 17
Position 2
Strength .... 11·61
Average deflection .... 24·91

Current in lamp circuit .... 144·60 amperes
„ „ field .... 2·95 „
„ „ armature .... 147·55 „
Resistance lamp circuit .... ·756 ohms
„ and field .... ·741 „
Total resistance of circuit .... ·7735 „
E.M.F. .... 114·13 volts
Electrical energy in lamp circuit .... 21·18 h.-p.
„ „ field .... ·43 „
„ „ armature .... ·95 „

Total .... 22·56 h.-p.

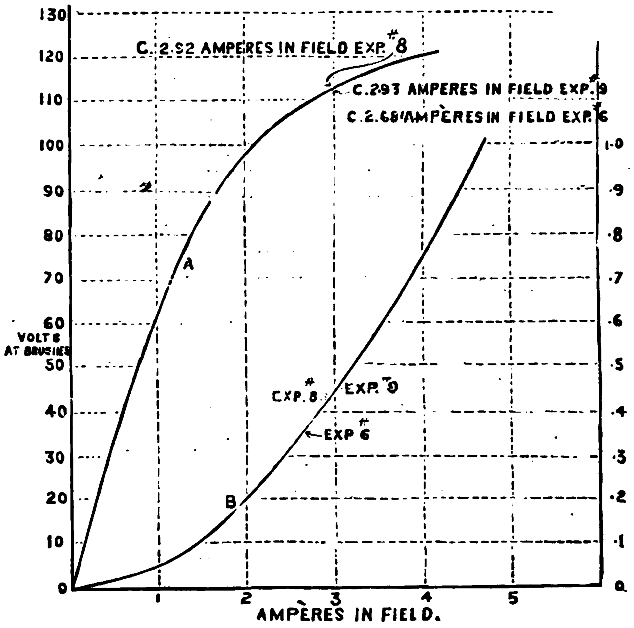

FIG. 6.

Dynamometer spring:—
At rest .... 112·23lb.
Running free .... 115·00lb.
Load .... 200·41b.
Total difference .... 88·17lb.
Above friction .... 85·40lb.
Total power to armature .... 24·56 h.-p.
Power above friction .... 23·79 „

Friction .... ·77 h.-p.
Dynamo speed .... 1·179
Dngine „ 315½
Efficiency of conversion .... 94·8 per cent.
Commercial efficiency .... 86·2 „
9·6 lamps per total h.-p.
9·9 „ „ absorbed h.-p.
10·5 „ „ h.-p. total electrical energy.
11·2 „ „ h.-p. electrical energy in ex. cir.

Same remarks about lamps and about behaviour of dynamo as were made in experiments No. 6 and 8 are pertinent to this experiment.

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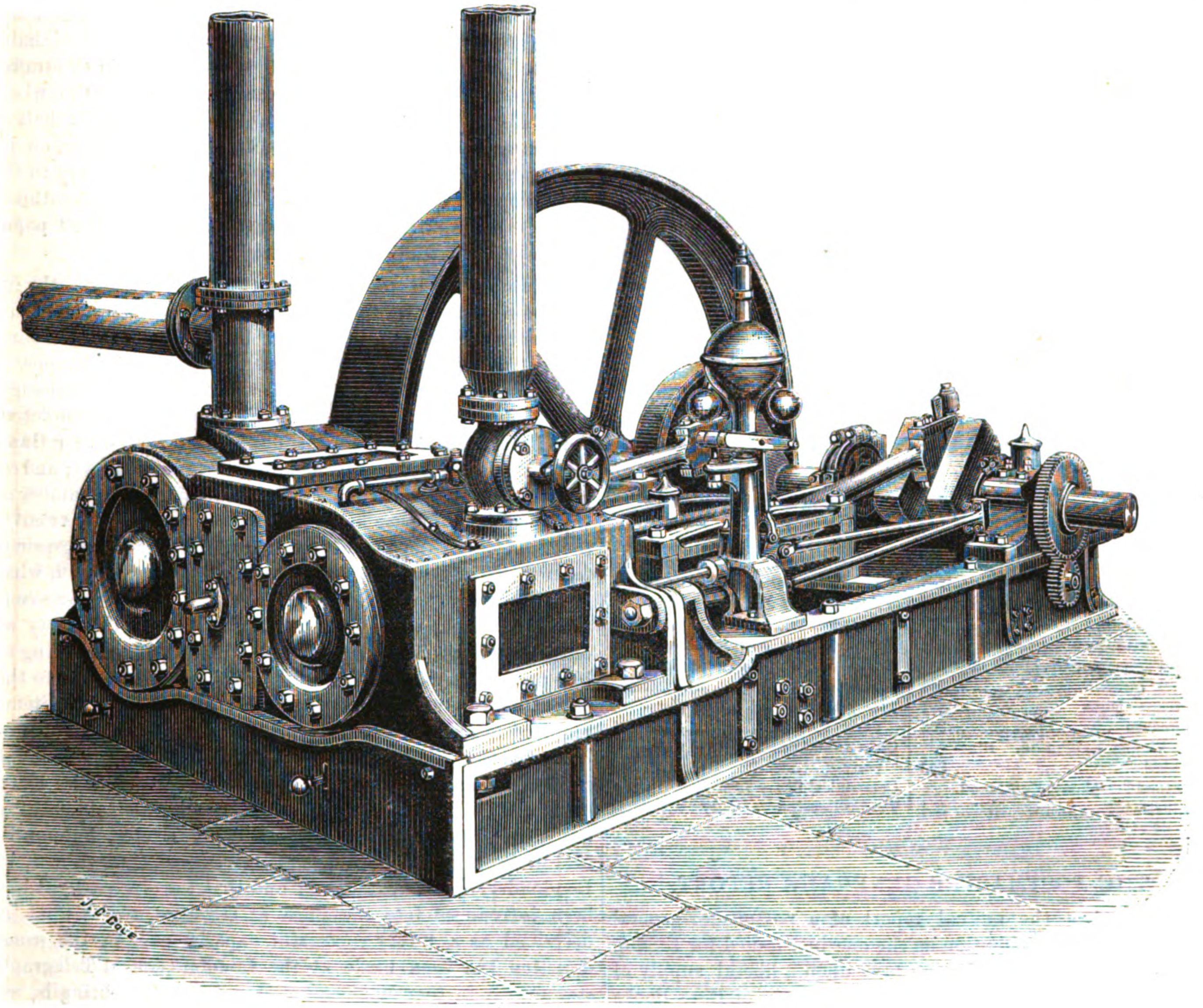
There was no appreciable increase in the heating, and the load could have easily been carried a long while. An increased load of 30 lamps could be carried some time.

THE FISHERIES EXHIBITION.—II.

The compound engine is illustrated by the perspective engraving which we give beolw. Its cylinders are high pressure, 15in. in diameter, and 24in. stroke; low pressure 22·5in. diameter, and the same stroke, the cranks being set at right angles, and making 103 revolutions per minute instead of 95, as intended, and as marked on the plan, which we have already published on page 201. The high pressure cylinder is fitted with Paxman's automatic cut-off gear, actuated by the governor, which is adjustable, so that the speed of the engine may be altered through a small range to suit the adjustment as to speed required by most dynamo machines. The exhaust steam from the high pressure cylinder passes into the space between the two cylinders which forms the receiver. The automatic cut-off valve has a very short stroke, so that only a small range of motion need be effected by the governor in order to control the engine and secure its uniformity of rotation under considerably varying loads. This is of the highest importance, for engines driving dynamos seldom run at more than from one-tenth to one-sixth their speed. Ten extra revolutions per minute of the engine thus make from 60 to 100 revolutions of the machine, and hence the necessity for controlling the engine speed to even half a revolution per minute. A governor should therefore be especially sensitive, because its action is always second to that of the engine. It can never anticipate the behaviour of the engine, and this, if the governor must be behind the thing it is to govern, should be as little behind as possible. This Messrs. Paxman secure by the arrangement we have described. We shall describe another of the large engines used for their work in our succeeding impression, and give further details. The governor is driven by gearing instead of by a strap, so as to avoid all risk of accident by the strap breaking or slipping off. Diagrams from this engine show that the distribution of the steam is all that can be desired. The ratio of expansion adopted is about 6, and this being effected in two cylinders, secures the advantage of high range of expansion without the loss due to refrigeration when large ranges are effected in one cylinder, and without the unequal strains thrown on the crank shaft by non-compound engines.



THE DAVY-PAXMAN COMPOUND ENGINE.

THE PATENTS FOR INVENTIONS BILL.—The report of this Bill was received in the House of Commons on Saturday last, and several verbal amendments and new clauses having been agreed to, the Bill was read a third time.

EVANSVILLE (IND.).—This American town has been satisfactorily lighted by the electric light from ten stages, each 150 feet high.

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THE ELECTRICIAN.

TO CORRESPONDENTS.

All letters intended for insertion in THE ELECTRICIAN, *or containing questions, must be accompanied by the name and address of the writer, not necessarily for publication, but as a proof of good faith. No notice whatever will be taken of anonymous communications.*

All communications to be addressed to 396, Strand, London, W.C.

We cannot undertake to return drawings or manuscripts, and must, therefore, request Correspondents to keep copies.

SUBSCRIPTIONS.

THE ELECTRICIAN *can be had, by order, from any newsagent in town or country, at the various railway stations; or it can, if preferred, be supplied direct from the office, on the following terms (paid in advance):—*

	3 months.	6 months.	12 months
	s. d.	s. d.	s. d.
For United Kingdom	4 10	9 9	19 6
„ Foreign Parts and Colonies:— Within Postal Union	5 6	11 0	22 0
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P.O. Orders to be made payable to JAMES GRAY, *at West Strand Post Office.*

ANSWERS TO CORRESPONDENTS.

C. E. M. (Buckhurst Hill).—*We think these are usually the ordinary medical coils, the strength being regulated by means of the core. We may be mistaken, however, and will write you if you can send any rough sketch of the apparatus you refer to.*

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THE POSTMASTER-GENERAL'S REPORT.

Seldom has the annual report of a postmaster-general attracted so little attention as the one just issued for 1882-3. Leader writers who generally count upon a liberal supply of material in the most popular and entertaining of Blue Books have this year found themselves hard pressed even to eke out a respectable paragraph from its contents. The report has none of those light and airy touches which used to illuminate its pages, and the anecdotical element in which it formerly excelled is now absent. Indeed, but for the reprint of a long extract from the first annual report ever issued, namely, that of 1855, and which is reproduced in the present report, *àpropos* of nothing in particular except its particular dulness, the pamphlet would have been greatly reduced in size as well as interest. The present Postmaster-General has confined himself to a purely business-like statement of affairs, and some ten small pages of large type embrace pretty well all that he has thought it worth while to say.

That portion of the report devoted to the telegraph branch of the Department is as meagre as the rest. We are informed on the first page that the estimated average number of letters posted per head of population is thirty-six. The value of statistics of this kind is considerably lessened by such facts as those mentioned on page 4, where we are told that one firm alone posted 132,000 letters in a single evening, and another forwarded 167,000 post cards, while circulars are often posted to the tune of 100,000 to 400,000 at a time by "individual firms." But for persons who find edification in these kind of figures it will interest them to know that, as the total number of telegrams amounts to over thirty-two millions, one telegram per head or thereabouts is now the average for the population of Great Britain. It does not exactly follow that everybody sends one telegram per annum; but the statistician is superior to detail. At the risk of upsetting his generalities, however, we notice that the inhabitants of London have by far the biggest share in the traffic. The metropolis represents about an eighth of the whole population, yet it sent nearly twelve million and a half of telegrams, more than one-third of the total number, on its own sole account. If we could reduce the area, say to the City proper, we should probably find that at least two-thirds of these telegrams emanated from there, though the "population" of that locality is almost *nil*.

It has not even yet been determined what form the intended reduction of tariff should take, but so soon as the necessary increase of plant can be effected, the minimum charge will be reduced to sixpence. Some steps it appears have already been taken which will facilitate the change, though decided upon before the reduction was contemplated. One hundred additional post offices and forty-five railway station offices have been opened for telegraph business; and an additional cable has been laid to Ireland, raising the number of wires available for use between the two countries to twenty-four. A cable depot, the site for which has been acquired from the War Office, is now erected at Woolwich, and, what is of still greater importance, a cable ship is being constructed which, when completed, will obviate the delay so often experienced in the repair of cables through having to hire private ships. No fresh information is afforded as to the extent of the additional plant over and above these items required to meet the pressure of the reduced tariff; but probably another annual report will be issued before that great revolution is accomplished. On some minor points we learn that additional telephone exchanges have been established by the Post Office at Newcastle-on-Tyne, Exeter, Falmouth, Middlesbrough, Plymouth, West Hartlepool, Cork, Limerick, Londonderry, and Waterford; and that the electric light has been introduced into the office at Glasgow, whilst what is described as a "very successful experiment" in the same direction has been made at the London Central Telegraph station. A further extension of this means of lighting is, we are told, under consideration.

This practically exhausts the items of interest for the past year. On one other point of equal, if not greater, importance, the report is uncommonly brief. There has, of course, been an increase in the number of messages forwarded during the twelve months, but the increase is below the normal figure, and far below what it had been during the preceding five or six years. This diminution in the rate of increase is dismissed very summarily. Naturally on the eve of reducing the rate a falling off of traffic is an inconvenient fact, not to be talked about overmuch. The Postmaster-General accounts for it partly by the occurrence of "two Easters involving four holidays in the financial year." But as there is usually one Easter in a financial year it follows that the diminution is only accounted for "partly" to the extent of

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one extra Easter, whatever that may involve. And as the difference between the increase of the past year and that of the preceding year is the difference between 746,165 and 1,933,879, the telegraphing public must have been taking a good many holidays besides those authorised in the calendar, and Mr. Fawcett might just as well have left it unconsulted. Business has not made its customary progress, that is all; let us be thankful it has not fallen off.

As regards revenue and expenditure, we have to turn to the tables in the appendix of the report to find out anything about these important items. The gross receipts appear to have increased at even more than the normal rate, some very considerable additions under the heads of News, Special Wire Rentals, and Private Wire Rentals mainly accounting for the satisfactory character of the figures under the head of Gross Revenue. It is only on turning to the Net Revenue that our satisfaction receives a disagreeable check. The year 1881-2 showed a serious falling off in net revenue, and this year it has fallen still lower. For the past three years the figures are respectively £368,815, £264,810, and £235,570. Of course the explanation lies in the working expenses, which have gone on increasing with greater rapidity than have the receipts. The latter—classed under the heading of total Telegraph Revenue, for 1880-1, 1881-2, and 1882-3, were £1,610,907, £1,630,443, and £1,740,063; whilst the working expenses charged to the Telegraph vote for those years amounted respectively to £1,242,092, £1,365,633, and £1,504,493. For our own part we see nothing to find fault with in these figures; the augmented expenditure is easily accounted for, and could not have been easily avoided; nor can the revenue be increased at pleasure even if Easters were altogether abolished. All the circumstances considered the net revenue is in a satisfactory condition, and, if left alone, would be in a fair way to recovery. But then we know it is not to be left alone.

CORRESPONDENCE.

ELECTRICITY, WHAT IS IT?

TO THE EDITOR OF THE ELECTRICIAN.

SIR: This is the first time I have rushed into print, and I am only induced to do so by the dreadfully confused state of the electrical units, and my desire to simplify them.

This proves to my mind that the originators of the British Association units, and others, did not base them on the true hypothesis. Had they done so we should have had but three electrical units instead of the numerous ones now used.

As my opinion is based upon a long experience in rendering electricity an useful assistant to commerce, it will be worth considering, if only calling the attention of the students to the cause of the confusion.

Some thirty-five years since, when I became acquainted with the science, electricity was generally supposed to be two fluids; then the one-fluid theory became more generally believed in. This not answering all the requirements of the science, I adopted the theory that electricity was a mode of motion, and not self-existent.

This is not quite the correct theory, or is, at all events, a very indistinct mode of stating it. I am now firmly of opinion that electricity does not exist. I mean in the same sense as motion, which also does not exist—viz., there is neither motion nor electricity where there is no matter. Thus, when we talk of motion, we really mean matter moved, and matter cannot be moved without force is applied to it. I therefore think we may safely say that motion is matter combined with force.

Electricity in like manner is matter combined with force, as I afterwards hope to prove.

There is considerable apparent difference between motion and electricity, the difference being, in the case of motion, the whole mass is displaced by the force applied; in the case of electricity (in a closed metallic circuit), it has the outward appearance of force being conveyed through the conductor without disturbing its particles or altering its structure, its presence being only known by its attendant magnetic radiation; but when we pass electricity through an interval, as in the electric arc, or through a conducting solution, then only does the disturbance of the particles become visible.

It is evident, then (if what I affirm be correct), that the study of electricity becomes the study of a property of matter.

According to my theory, nature has only two properties, namely, matter and force. I request the reader to accept this latter as the basis of my argument.

I will now try to prove what electricity is, and what electric units should be. The names I shall use are those of the B.A. units, viz., the weber, volt, farad, ohm, and second, and compare them with the mechanical units they so much resemble.

But first let me state that:—

Positive electricity is a condition of matter trying to disintegrate or dissolve.

Negative electricity is that state of matter trying to accumulate.

Our mechanical units are the pound, the foot, and the second.

The pound is the unit of mass only and has no force of itself.

The foot (or more properly the earth attracting through a foot) also has no force alone, but the unit of force which actuates the unit of mass gives a compound unit of force—the foot pound.

The second is the unit of time during which the force is exerted, and enables us to calculate the total force exerted during any given period.

You will perceive, then, that three units only are required for mechanical force measurements, and as electricity so nearly resembles motion, the same number only are required for electrical force measures and are:—

1. The mass of matter combined with electrical force, which is the weber. This stands in the same relation to the electrical as the pound does to mechanical force.

2. The amount of force actuating the mass, which is the volt, and takes the place of the foot in mechanical force.

3. The second is exactly the same in regard to both electrical and mechanical forces.

Before the reader is capable of comprehending my ideas respecting electrical units, he will require some considerable explanation, more particularly to understand the weber, to do which I must again compare it with motion. A pound thrown across a space does not become heavier or lighter whether sent with a small or great force. Neither is the weber affected whether sent across a space with great or small volt force. I must now inform the reader what the weber is in terms of mechanical force. It is $\frac{1}{3000}$ gramme of zinc, but different in other substances according to their atomic weight, and is that quantity of metal which is dissolved from the + plate and deposited on the − plate, by an electric current of one volt through one ohm in one second. This quantity always remains constant, no matter if the weber current be of one or any number of volts, strain, or pressure, or during any time. Therefore I may aver that that amount may be taken as the quantity of matter with which the force is combined.

In like manner as the pound thrown across the space is no measure of the force it carries, so with a weber current, it is no measure of the force it conveys, it being simply the amount of matter with which the force is combined, but the compound unit of mass × force.

Weber × volt = force or work done, and bears the same relation to electrical force as the foot-pound does to mechanical.

I am afraid I have not made myself so distinctly under-

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stood as I should like, but it is impossible in a short letter to give the experiences of years.

To show the fallacy of many units used, I append the following :—

A weber is the electrical unit of mass $\frac{1}{3000}$ of a gramme of zinc, and is that electrical current which deposits that amount of zinc, whether during long or short period, or, in other words, the amount of matter with which force is combined.

A weber current is that current which deposits $\frac{1}{3000}$ of a gramme of zinc per second, and I think that a veber second would be a more suitable term.

A volt is the unit of electrical strain or pressure.

A volt weber is a compound electrical unit of force conveyed, and occupies the same position to electric as the foot-pound does to mechanical force.

These three units—weber, volt, and second, with the compound unit volt weber, are all the units required for electrical force measurements.

The ohm is an useful mechanical unit for electric construction, and has a resistance of one to one volt, $\frac{1}{2}$ to two volts, $\frac{1}{10}$ to 10 volts, and so forth.

The following units appear to me not only not necessary, but confusing—viz., a farad means the same quantity as a weber, but has reference to an inductive surface that will hold a weber, with one volt strain, and bears the same relation to a weber as a quart measure does to a quart. A better name for a farad condenser would be a weber condenser.

Coulomb, watt, &c., are only other names for a volt weber.

The ampere is only another name for a weber.

In my opinion these and numerous other names in the electrical nomenclature should be discontinued.—Yours, &c.,

THEOPHILUS VARLEY.

High-street, Walthamstow.

EMMENS'S BATTERY.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In reply to Mr. Taguet's letter in your issue for the 4th inst., I beg leave to state that the batteries invented by Mr. G. C. V. Holmes and myself are patented by letters patent, and can only be made under license from us. We have not, as yet, published any detailed description of the batteries in question, but the following particulars may perhaps be interesting to your readers :—

OXYDONE CELLS.—These are double fluid combinations in which an acidified solution of our "oxydone" is used as the dehydrogenising agent. Automatic charging and discharging appliances are provided, together with an efficient fume-arresting apparatus. The cells are made in three sizes, one-third, two-third, and one and one-third horse-power. The E.M.F. is 1·75 volt, and the internal resistance lower than has hitherto been obtained with primary batteries. The residual products may be commercially utilised, and may be made to pay the cost of working.

BISULPHATE CELLS.—These are of the Daniell type, with a modified solution of copper, and other peculiarities, having for their result a marked diminution of internal resistance. The E.M.F. is but little in excess of an ordinary Daniell cell, but the current is larger and more constant. We have used them successfully for both public and private lighting.

TRICHROME CELLS.—These are single-fluid cells in which an aqueous solution of our "trichrome" is employed. The E.M.F. is equal to that of a bichromate battery, but the internal resistance is less, and the constancy far greater. No fumes are evolved, and the manipulation is of the simplest possible character.—Yours, &c.,

Aug. 7, 1883. STEPHEN H. EMMENS.

EDUCATIONAL.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Could any reader of *The Electrician* kindly inform me of the best way of taking up electricity as a profession, *i.e.*, attaining position as electrical engineer, or similar capacity ?

Have had fair theoretical training in electricity, and practical in an amateur's style.

Is there any good institute not far from London Bridge where it is possible to get a thorough practical training of an evening ?

For any information or suggestions as to the best steps to take I shall be most grateful.—Yours, &c.,

CONSTANT READER.

LITERATURE.

Die Elektrolyse Galvanoplastik und Reinmetallgewinnung.

This little treatise is one of a series of very useful books on electric technology now being published by A. Hartleben, of Vienna, Pesth, and Leipsig. It is a brief compendium on electroysis, electro-deposition, and the extraction of pure metals from their ores, crude alloys, and impure solutions by means of electrolysis. It treats of—1. The electric current and its chemical action, electrolytic conduction, electro-chemical equivalents. 2. Theories of electrolysis. 3. Voltaic batteries and thermopiles. 4. Magneto-electric and dynamo-electric machines for electrolytic operations. 5. Choice and arrangement of electro-motors for those purposes, apparatus for regulation of currents, &c. 6. Apparatus and implements for electrolytic operations. 7. Electrolytic analysis. 8. Electro-deposition of copper, brass, tin, zinc, nickel, gold, and silver. 9. Electro-metallurgy, electrolytic separation of pure copper from its ores, separation of zinc, magnesium, aluminium, the electric furnace, and 10. Other industrial applications of electrolysis in the manufacture of soda, also in bleaching, dying, &c.

As the book is a small one, consisting of only about 260 pages, and is printed in large open type, the whole of these subjects are necessarily treated in a very brief manner. The matter is, however, well illustrated by forty-six suitable and well executed engravings.

To those who wish to make themselves acquainted with the most recent industrial applications of electrolysis, the book will prove very acceptable, especially in the subject of electro-chemical analysis, and the quantitative electrolytic determination of heavy metals in alloys, minerals, metallic regulus, and the other metallic products, such as the metalliferous solutions of mines, and also the subject of the separation on the large or commercial scale of copper from crude copper regulus, and from cupriferous solutions as occurring in mines, or arising from the treatment of metalliferous earths or of roasted ores by means of various acids and saline liquids.

The processes of Elkington, Clark, Cobley, Keith, and others, for the electrolytic separation of copper, lead, silver, zinc, and other metals, together with some data respecting the cost and degree of purity of the metals obtained, are briefly stated. The electro-depositing powers of dynamo-electric machines of different construction, the amounts of mechanical power they consume, and other useful data of a practical kind are also given. The greater portion of the book, however, is occupied with the subject of voltaic and thermo-electric batteries, and with the ordinary processes of electro-deposition and of electro-plating.

Whilst this publication will prove a very acceptable one to electro-metallurgists in particular, its chief defect as a new book is the brevity of its information respecting the most recent applications of electrolysis, and the incompleteness of its references to the sources of such information.

NUMBERS OF "THE ELECTRICIAN" OUT OF PRINT.—The following numbers of *The Electrician* are out of print, and cannot be supplied at the office, viz. :—Vol. 1, Nos. 3, 9, 19 ; Vol. 7, Nos. 8, 10, 12 to 18, 20, 21, 24 to 26 ; Vol. 8, 1, 3, 6 to 12, 15 to 26 ; Vol. 9, Nos. 2, 4, 24, 25 ; Vol. 10, No. 13.

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THE VIENNA EXHIBITION.

The plan of this exhibition, given in to-day's issue, indicates roughly the position of the exhibits. Our correspondent informs us that the exhibits are still in a very backward state, and it is doubtful if they will be fairly ready before September. We believe the following to be a correct list of the English exhibitors:—

TELEGRAPH CONSTRUCTION and MAINTENANCE COMPANY, 38, Old Broad-street, E.C. Specimens of submarine cables and gutta percha core.

M. BAUER and Co., London. Lighting apparatus.

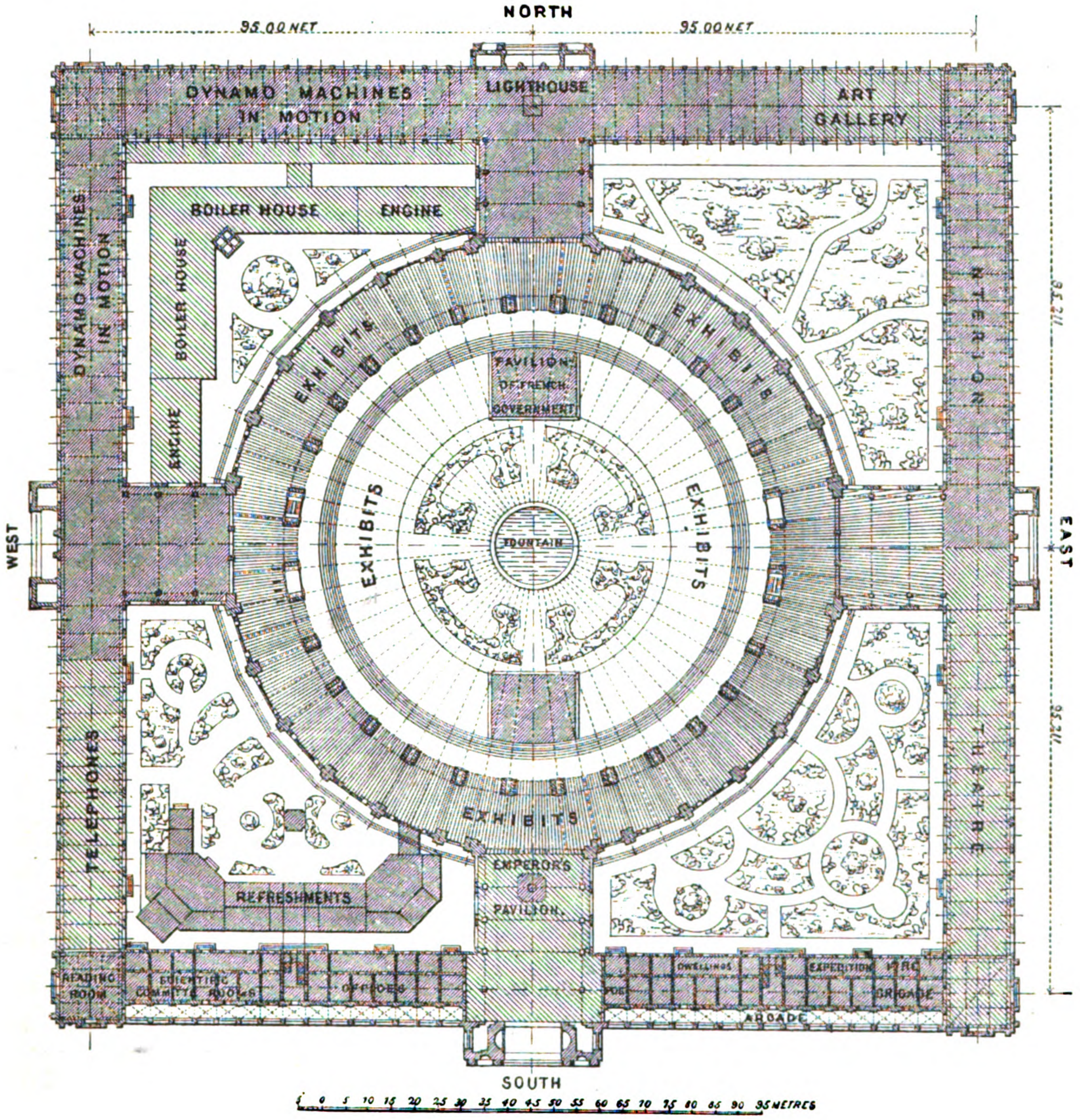
ROBEY and Co., Lincoln. Steam engines and boilers.

ELECTRO-DYNAMIC COMPANY OF PHILADELPHIA, 2, Scott's-yard, Bush-lane, Cannon-street, E.C. Electro-motors for domestic and industrial purposes.

DUPLEX ELECTRIC LIGHT, POWER, and STORAGE COMPANY, 9, Soho-square, W. Batteries, dynamo machines, arc and incandescent lamps.

ELECTRICAL POWER STORAGE COMPANY, 4, Great Winchester-street. Accumulators; ship driven by accumulators.

CHARLES LEVER, 87, Euston-road, London. Six arc lamps.



PLAN.--VIENNA EXHIBITION.

KILLINGWORTH HEDGES, 25, Queen Anne's-gate, Westminster. Spark-reducing switches, safety plugs, ammeter, &c.

J. SLATER LEWIS, 28, Hamilton-street, Birkenhead. Self-binding telegraph insulators.

J. STIFF and SONS, Lambeth, S.E. Porous cells, battery jars, insulators, &c.

LIEPMANN CARBON COMPANY, Nelson Wharf, Millwall, E. Carbons, battery plates, &c.

COXETER and NEHMER, 23, Grafton-street East, Tottenham Court-road, N.W. Dynamo machine and telephones.

J. COXETER and SON, 23, Grafton-street East, Tottenham Court-road, N.W. Medical batteries and electric bath.

CHARLES FOSTER and Co., Birmingham. Miniature gas-motors, batteries, and apparatus for students.

THAMES IRON WORKS and SHIP BUILDING COMPANY, Orchard-yard, Blackwall. Hodson's patent high speed rotary engines.

THE EASTERN TELEGRAPH COMPANY, 66, Old Broad-street. Submarine telegraph apparatus.

E. S. HINDLEY, Bourton, Dorset. Twelve horse-power horizontal steam engine, cylinder 11in. diameter, 15in. stroke, with high speed equilbrium governor.

ELPHINSTONE and VINCENT, 79½, Gracechurch-street, E.C. Dynamo machine to drive 400 20 candle-power Swan lamps or a corresponding number of arc lamps or incandescent and arc lamps at same time.

H.M. POSTMASTER-GENERAL, London. Display of historic modern telegraph apparatus.

CROSSLEY TELEPHONE COMPANY, London. Telephones.

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T. R. Crampton, 4, Victoria-street, Westminster. Portion of the original cable laid between Dover and Calais in September, 1851.

The India Rubber, Gutta Percha, and Telegraph Works Company, Silvertown, London, England, and Persan, France. Electric lighting apparatus.

Walter Glover and Company, Manchester. Electric lighting material.

P. C. Addison and Company, London. Driving pulleys.

Hudswell, Clark, and Company, Leeds. Driving pulleys.

Ruston, Proctor, and Company, Lincoln. Steam engines.

International Electric Company (formerly the Anglo-Austrian Brush Company), 4, Copthal-buildings, London; 43, Campner-strasse, Vienna. Electric light apparatus.

PRACTICAL TELEPHONY.

(continued from page 284.)

The reference letters used in describing testing for faults, &c., in last as well as the present issue, refer to Figs. 22, 23, and 25, page 136, June 23, 1883.

Signalling Good in both Directions but Speaking and Receiving Broken Down.—First join terminals L and E with a short piece of wire, and tap transmitter to make sure the fault hinge J, frame B, carbon G, spring C (at this stage the wire of detector under T Z must be moved from T Z to C), hinge I, terminal 1. The deflection will occur at each point touched until the fault is passed, when it will be found between the last two points touched. When found rectify. If the fault, however, is between terminal 2 in transmitter and hinge J, the primary wire is broken, and if inside the coil itself the transmitter must be changed. Care must be taken to see that the springs carrying the carbon button G and the spring C do not touch each other anywhere; only the carbon button and platinum point should be in contact. When inspecting the primary or local circuit it is advisable to test with galvanometer and battery cell to see that the iron frame and diaphragm are insulated one from the other, as contact will cause failure in transmission. A piece of paper must be placed between the carbon button and platinum point during this test.

Humming and Rasping Sounds in Telephone.—A continuous humming noise is caused by the transmitter being too loosely adjusted, or the local cell being too strong. First touch the diaphgram of the transmitter; if that stops the sound screw up the adjustment a little, but if the singing continues, unless the transmitter is too tightly adjusted for perfect transmission, a resistance of 2 or 3 ohms must be inserted in the local circuit until the battery weakens. Rasping sounds are caused by the carbon buttons being rough when in contact with the platinum point. To remedy this, slacken the screws in insulated block H, and move the carbon up or down the slightest degree, so that the platinum point may work on a fresh spot. These sounds are also caused by dust in the local cell contact, and the spring not

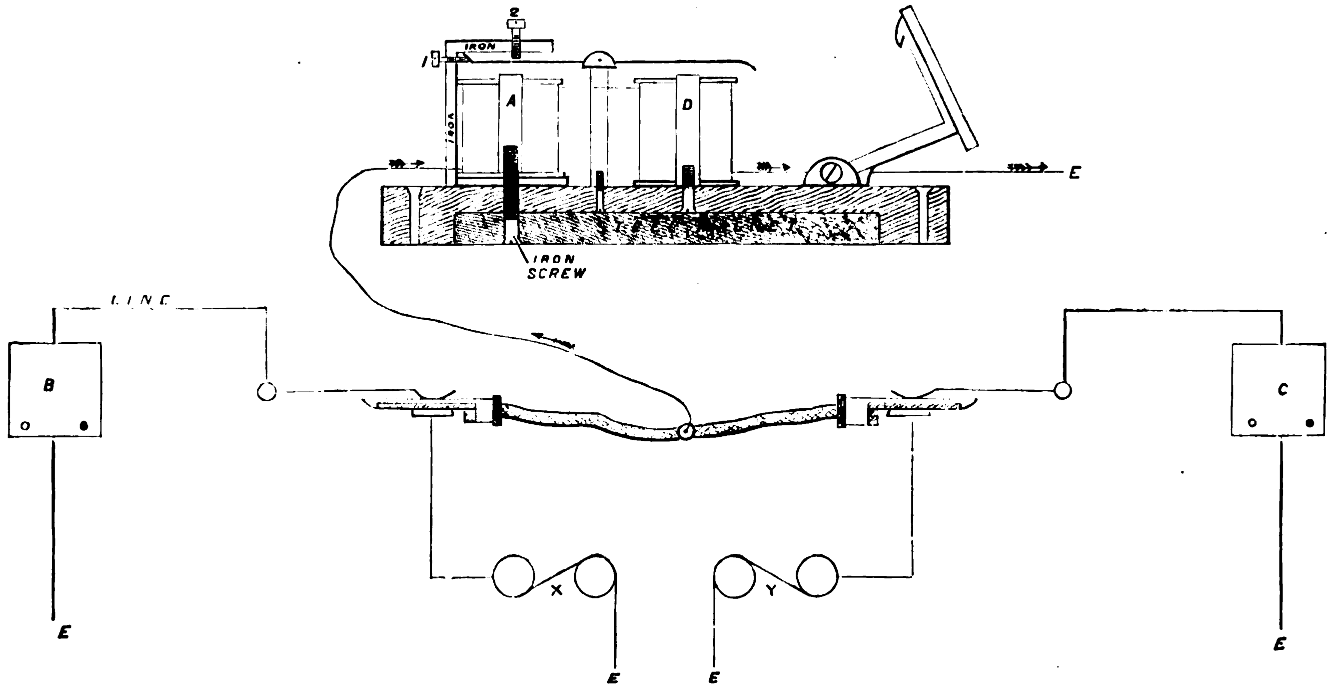

Fig. 51.

is at your station. Supposing you get no sound, disconnect the short piece of wire from terminal E, letting it remain in terminal L, hold the telephone to your ear and touch terminal C with the end of the wire that was under terminal E. If you get a sound, the trouble is in the primary circuit, if you get no sound by touching C as before, see that the telephone switch contact spring is in good contact with the switch hook disc. If this is OK, replace the telephone cord by two wires; if you now get a sound the trouble is in the cord; if the telephone is still dumb, join terminals 3 and 4 in the transmitter, and touch C again. If you get a sound the fault is in the secondary coil, unless the wires leading to it from 3 and 4 are damaged; if so, repair with 24 silk wire, making a tight twisted joint, if not, the transmitter must be changed. Supposing the fault is traced to the primary circuit by the test indicated above, there will still exist some fault outside the instrument that prevents speech being received. This had, however, be better left till the local circuit is attended to. Again join L and E by means of a wire, make sure that your local cell contact is good, and that the cell itself is in good order. Then join one wire from your detector (using the thick wire coils) under T Z (keeping the telephone off the hook). With the other wire from detector touch C; if the local cell and wires therefrom are in good order the usual deflection will be observed, then touch in succession local cell contact stud, local cell contact spring, terminal 2 in bell case, terminal 2 in transmitter, pressing tightly enough against the contact stud. This refers to those instruments that have dotting contacts for local cell, some of the later form have rubbing contacts for local cell, which is an improvement in the respect that dust cannot stop the contact, but any vibration or jar causes the contact to act as a microphone, often causing an intolerable noise. To remedy this, make the contact as firm as possible, then apply the slightest touch of sweet oil, which will at once stop the noise. With this class of fault it is advisable to first localise it by joining L and E, as it may exist at the other station. If it continues when L and E are joined it is doubtless at your station. If the rubber glove or damper K, or rubber ring E become soft or sticky, the speaking may be much impaired. To remedy this, insert a piece of paper between the glove and the diaphragm in the first case, and a ring of paper between rubber and iron frame B in the second instance. In all manipulations with a transmitter remember it is a delicate instrument, therefore make all repairs and alterations carefully; do nothing hap-hazard in the hope that you may light on the fault, but trace it out carefully, and in any case use your eyes well first.

Faults in Switch Room.—If due care be taken these will not be very frequent or serious. Possibly after a thunderstorm several of the annunciator coils will be found spoilt, and then those that can be taken out and replaced without disturbing the others will be appreciated. It is a good plan to have an annun-

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ciator connected locally in the switch room, thus—one terminal to a stud easily accessible, the other terminal to earth through a resistance of, say, 100 ohms, or whatever resistance the contact stud; then ring up, and if the shutter falls the fault is elsewhere. If in ringing up a subscriber the drop falls but his bell does not ring, the fault is probably outside the room,

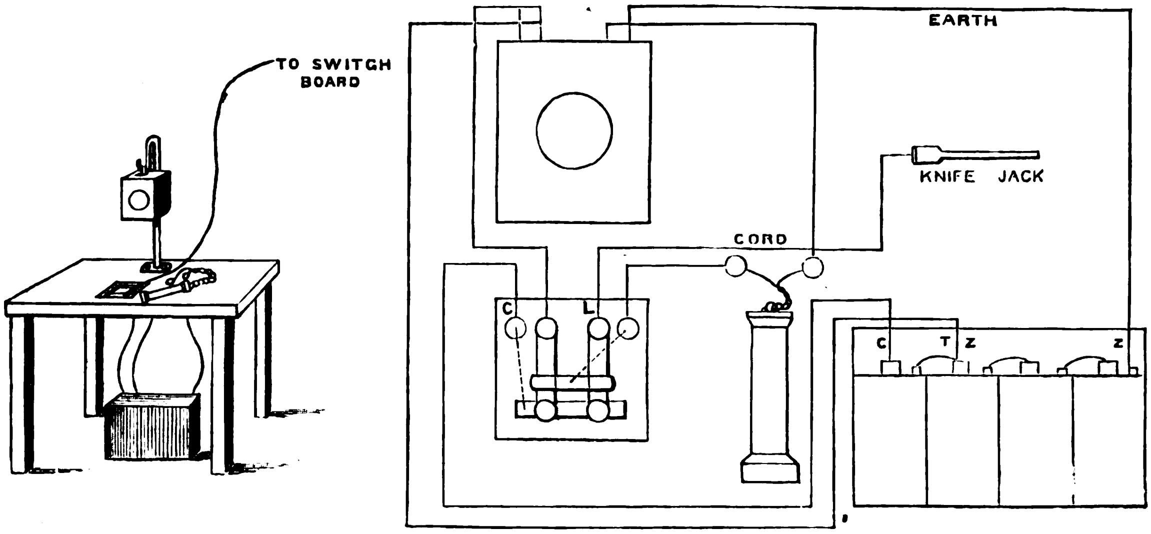

Fig. 52.

the battery when in good order is capable of working through. If a cord or table is suspected, the board operator holds the jack on the contact stud; the table operator then rings up. If the and a visit must then be paid to the subscriber, and his instruments and line tested as previously described.

Special Method of Connection, Leaving Subscribers

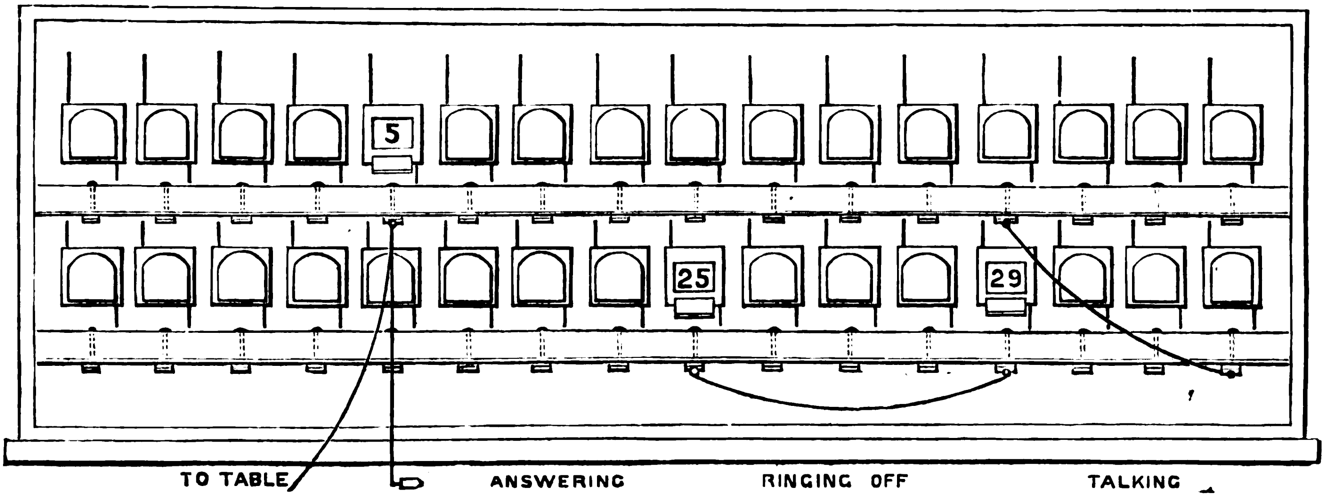

Fig. 53.

shutter does not drop the fault must be traced out. If a subscriber cannot be called, and his shutter does not drop, attach a

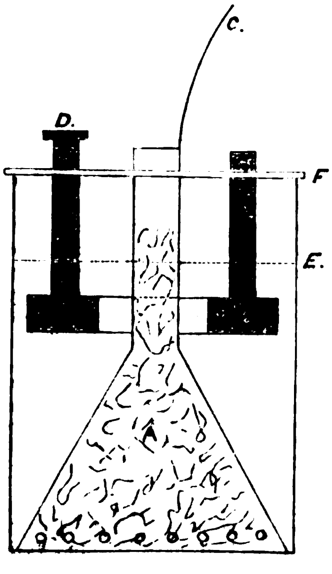

Fig. 54.

wire from the line terminal of his annunciator, and touch it in

Through when Exchange is Closed.—This can be done by using the four-point switch as shown at Fig. 13, or leaving them connected by the jacks in the ordinary way.

Polarised Cut-off Annunciator (in Switch Rooms.)—Fig. 51 shows a mode of connecting subscribers which is more complicated, but has certain advantages. When the polarised indicator is in its normal state the induced magnetism in core A holds down the armature, and keeps the disc up, the movement of the armature being regulated by screws 1 and 2. A + or copper current passing through coils in direction shown by arrow only tends to strengthen attraction of A, but a — current neutralises A and strengthens D, and so releases the armature. The coils are wound with very fine wire to a high resistance, B and C are subscribers' instruments having two buttons, black and white (see page 127, June 23), the former to send a negative and the latter a positive current. When two lines are joined *through*, the annunciators X Y belonging to those lines are cut out. The cord (or other means used to connect the lines) has a wire joined up to it leading to the finishing or "ringing off" signal, as above described. When two subscribers are through they may leave their instrument afterwards, ring one another up by pressing white button, this signal passing through the central office without dropping any signal. When finished the black button is pressed, which drops the indicator, giving the "cut off" signal.

Operating Table.—Fig. 52 illustrates the ordinary form of table, as described on page 257, July 28.

Fig. 53 illustrates mode of operating slipper board system, as described at page 258, July 28. No. 5 call is being answered.

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Nos. 25 and 29 have "rung off." Nos. 13 and 32 are connected for speaking.

Fig. 54 illustrates the battery described on page 35, May 26. A. Lead funnel. C. Lead strap. D. Zinc. E. Level of solution. F. Wood or porcelain cover.

(TO BE CONTINUED.)

A HISTORY OF ELECTRIC TELEGRAPHY TO THE YEAR 1837.

BY J. J. FAHIE, MEMB. SOC. TEL. ENGS. AND ELECS.*

(CONTINUED FROM PAGE 286.)

CHAPTER III.—TELEGRAPHS BASED ON STATIC, OR FRICTIONAL, ELECTRICITY.

1782.—ANONYMOUS TELEGRAPH.

The next proposal, which is an exceedingly interesting one, is contained in an anonymous letter to the *Journal de Paris*, No. 150, for May 30, 1782, a translation of which we append:

To the Authors of the Journal,

A way of establishing a communication between two very distant places has been proposed to me, and those of your readers who care for this kind of scientific amusement will not, perhaps, be angry with me for telling them what it is.

Let there be two gilt iron wires put underground in separate wooden tubes filled in with resin, and let each wire terminate in a knob. Between one pair of knobs, connect a letter formed of metallic [tin-foil] strips after the fashion of those electrical toys, called "spangled panes"; if, now, at the other end we touch the inside of a Leyden jar to one knob, and the outside to the other, so as to discharge the jar through the wires, the letter will be at the same instant illuminated.

Thus, with twenty-four such pairs, one could quickly spell all that was desired, it being only requisite to have a sufficient number of charged Leyden jars always ready.

As it would not be necessary to make the letters very luminous, a slight indication being sufficient, complete darkness would not be required for the perception of the characters; feebly charged jars would, therefore, suffice, which would greatly facilitate matters. The letters may even be suppressed, and then there would be one instrument common to the twenty-four systems (pairs) of wires [*sic*].

These means could be simplified by having only five pairs of wires, and attaching a character, or letter, to each of their combinations, 1, 1°, 2, 2°, * * 5, 5°, 1, 1°, and 2, 2°, 1, 1°, and 3, 3°, * * 1, 1°, 2, 2°, and 3, 3°, and so on, which would make thirty-one characters; six pairs of wires would, in the same way, yield sixty-three, and thus one could arrive at a sort of tachygraphy, or fast writing, one character (or signal) sufficing for a whole word, or phrase, as may be previously agreed upon. There would be some difficulty, however, in discharging at exactly the same instant several (separate) jars through as many separate pairs. One might also use successive combinations of these pairs, 2 to 2, 3 to 3, and so on, in which way five pairs would give 125 signals, and six 216, which would be very fast writing indeed.

The wooden tubes might, very probably, be unnecessary; but in view of accidents, such as fractures, it would always be safer to employ them.

One could use *simple* electricity [*i.e.*, direct from the machine], and so greatly simplify the apparatus, but as the superficial area of a great length of wire, even when a very fine one was used, would be considerable, this plan would necessitate very powerful machines. In either method, however, the object could easily be obtained by using very large *electroferoi*.

It would be necessary to give each correspondent a means of notifying that he wished to communicate, to prevent constant watching and cross signalling. For this an electric bell would suffice, and by agreeing beforehand that one stroke shall mean "I will call you up in 15 minutes," two strokes "I am all attention," &c., all confusion would be avoided.

As this letter is only intended for those who amuse themselves with physics, they can easily supply for themselves all the details that I have omitted.

I have the honour to be, &c.

This letter is copied, almost *verbatim*, in *Le Mercure de France*, for June 8, 1782, and is also embodied in a letter, dated June 5, 1782†, where the writer prefaces it with the following remarks: "We have Linguet once more installed in the career in which his labours have been so disagreeably interrupted. His project of an easy communication between two very distant places appears to be only the dream of some pleasant trifler. It is, however, not new, and would only imperfectly accomplish its object; but still there may be some good in it."

In these remarks Metra somewhat mixes his facts. There is no more authority for the statement that Linguet was the writer than that he, at this time, was engaged on experiments on some kind of a *luminous* telegraph, which, as we have shown in our Chapter II., Part I., he planned while a prisoner in the Bastille, and in exchange for which he is popularly, though erroneously, supposed to have received his liberty. On the other hand, we have positive proof that he was not the writer, firstly, in the opening sentence of the letter itself, and secondly, in the following passage from his "Memoires sur la Bastille," which, for convenience, we reproduce here:—"I will one day make known my ideas on this subject [of signalling by means of light]. The invention will certainly admit of being greatly improved, as I have no doubt it will be. I am persuaded that in time it will become the most useful instrument of commerce, and all correspondence of that kind; just as electricity will be the most powerful agent of medicine; and as the fire-pump will be the principle of all mechanic processes which require, or are to communicate, great force" (Note 13).

1782.—LE SAGE'S TELEGRAPH.

On seeing these accounts, George Louis Le Sage,* a *savant* of French extraction, residing at Geneva, published a somewhat similar method, in a letter, dated June 22, 1782, and addressed to his friend, M. Prévost, at Berlin.

He writes: "I am going to entertain you with one of my old discoveries, which I see has just been found out by others, at least, up to a certain point. It is a ready and swift method of correspondence between two distant places by means of electricity, which occurred to me thirty, or thirty-five, years ago, and which I then reduced to a simple system, far more practicable than the form with which the new inventor has invested it.

"I have often spoken of it to one or two persons, * * * * * but I see no reason for supposing that my co-inventor has drawn his ideas from these conversations. The thing is so natural that, to discover it, it is only necessary that one should be in search of some means of very rapid correspondence; and people have, on occasion, turned their minds to this subject * * * * * *, as, for example, Mr. Linguet.

"But it is time to tell you briefly in what my plan consisted. One can imagine a subterranean tube, of glazed earthenware, the inside of which is divided, at every fathom's length, by diaphragms, or partitions, of glazed earthenware, or of glass, pierced by twenty four holes, so as to give passage to as many brass wires, which could in this way be supported and kept apart. At each of the extremities of this tube, the twenty four wires are arranged horizontally, like the keys of a harpsichord, each wire having suspended above it a letter of the alphabet, while immediately underneath, on a table, are pieces of gold leaf, or other body that can be as easily attracted, and is, at the same time, easily visible

"He, who wishes to signal anything, shall touch the ends of the wires with an excited glass tube, according to the order of the letters composing the words; while his correspondent writes down the characters under which he sees the little gold leaves play. The other details are easily supplied"

Le Sage had an idea of offering his invention to Frederick the Great, and drew up an introductory note as follows:—

"To the King of Prussia

"Sire

"My little fortune is not only sufficient for all my wants, but even for all my tastes—excepting one, viz: that of contributing to the wants and tastes of others; and this desire all the monarchs of the world, united, could not enable me to fully satisfy. It is not, then, to a patron who can give much, that I take the liberty of dedicating the following discovery, but to a patron who can do much with it, and who can judge for himself of its utility without having to refer it to his advisers."†

* The author reserves all rights of translation.

† In Metra's "Correspondance Secrète," &c., Londres, 1788, Vol. 13, page 84. Mr. Aylmer, to whom we are indebted for the copy of this letter which appeared in *Le Mercure de France*, tells us that the Comte du Moncel attributes it to Le Sage, but we shall presently see reasons for doubting this.

* "Upon the present venerable and learned M. le Sage of Geneva devolved, in a great measure, the education of Lord Mahon, who is frequently heard to mention the name of his preceptor with considerable respect. He even goes so far as to pronounce M. le Sage the most learned man in Europe." *Vide* Life of Earl Stanhope, in *Public Characters of* 1800-1801. London, 1801, p. 88.

† See "Notice de la vie et des écrits de George-Louis Le Sage de Genève," etc, par Pierre Prévost, 8vo., Genève, 1805, pp. 176-7; and *Le Journal des Sçavans*, for September, 1782, page 637, 4to., Paris. All writers on the Electric Telegraph, copying Moigno ("Traité de Télégraphie Electrique," Paris, 1849 and 1852), say that Le Sage actually established his telegraph at Geneva in 1774—an assertion for which we have not been able to find any authority.

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Whether he ever carried out this idea or not is difficult to say, but it is certain that his plan was never practically tried, and, like so many of its class, was soon forgotten.

(TO BE CONTINUED.)

ELECTRO MOTORS AND THEIR GOVERNMENT.*

BY PROFESSORS W. E. AYRTON, F.R.S., AND JOHN PERRY, M.E.

The near approach of electric mains being laid under our streets, and the facilities they will offer for supplying electric power during the day-time to factories, workshops, and even to private houses for domestic purposes, lends an immediate importance to considerations regarding the best form that should be given to electro-motors, as well as to the best conditions under which they should be used; while the comparatively novel question as to the methods that can be employed for governing motors, so as to make them run at the same speed whatever work they may be doing, is of equally pressing importance, seeing that this condition of constant speed must necessarily be fulfilled before we can expect to see lathes, circular saws, and other tools in our workshops regularly driven by electro-motors.

The great value of electro-motors arises—

1st, from their portability, seeing that they need only be connected by means of a pair of thin flexible wires with the main supply cables.

2nd, from their small weight per horse-power developed by them.

3rd, from the possibility of their being used at a considerable distance from the prime mover.

4th, from their working to the best advantage when run fast, and so being especially suitable for driving quick-moving machinery direct, without any intermediate gearing; for in a factory there is a great loss of power arising from the friction of a long line of shafting turning in its bearings, and, secondly, there is a loss of power in the intermediate gearing employed to make the drill or other quick-moving tool revolve much more rapidly than the shaft.

The portability of motors enables us to bring the machine-driven tool to the work, instead of, as at present, the work to the tool. For example, Fig. 1 shows a circular saw directly driven by one of our motors, and which can be moved about with tolerable convenience. Again, Fig. 2 shows an emery wheel also driven by one of our motors, and which can be moved about for the purpose of polishing any large piece of metal.

The third and fourth advantages make electro-motors of especial importance to us Londoners at this present moment.

The unsightly blow-holes on the Thames Embankment and at this end of Victoria-street have now fallen out of favour, if they ever were in favour. Although English people are not supposed to be strong in matters of taste, we still cannot contemplate with equanimity a series of low chimneys emitting foul gases scattered along our principal thoroughfares, especially when perfect ventilation can be obtained by fans directly driven by motors. Such a fan (kindly placed at our disposal by Rev. Mr. Capell) is shown in Fig. 3, 3ft. in diameter, which is now passing 16,000 cubic feet per minute at 1,000 revolutions, and is driven by one of our motors, the electricity being supplied by Faure-Sellon-Volckmar accumulators kindly lent us by the Electrical Power Storage Company. These fans might be stationed along the tunnel, each driven directly by a motor without intermediate gearing. A single going and returning insulated wire would convey an amount of power which seems incredible to a mechanical engineer; and a steam engine doing the work, as well as a dynamo machine supplying the electricity, might be all in some back yard out of everybody's way. The gas might be sent into the water of the Thames, and if even the bubbling up of the gas was thought objectionable it might bubble up in recesses in the walls, so that the bubbles could not be seen. The particular specimen of our electro-motors which we are employing this evening has adjustable lead and reversing gear; this, of course, would not be necessary for motors permanently fitted and always run at a fixed speed, but it is very handy for motors when used experimentally. The details of the reversing gear can be seen from figures which come later on in this paper, where a description of the gearing will be found.

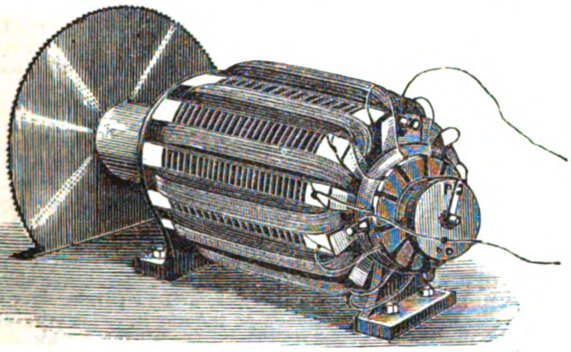

Fig. 1.

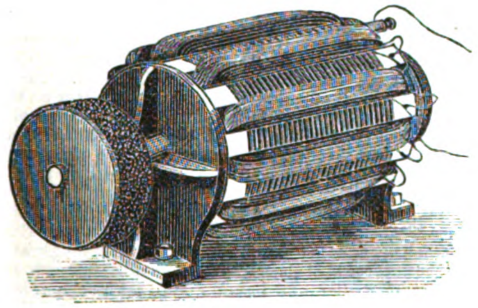

Fig. 2.

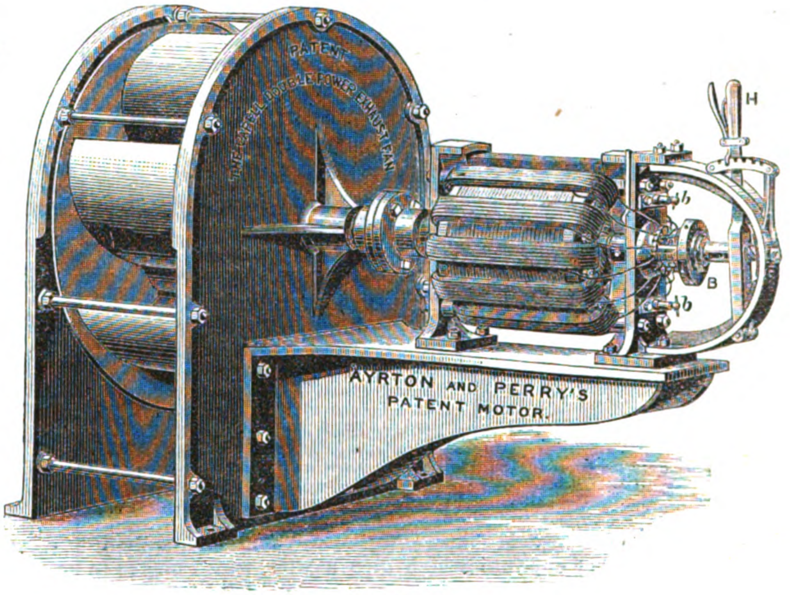

Fig. 3.

The smaller 2ft. fan, which is being driven also by one of our motors, is passing about half the quantity of air.

The portability of electro-motors and their light weight make them of enormous importance where locomotion is involved. It may be in the memory of some of those present that a year ago we advocated the automatic electric transport of goods and passengers by means of electric railways without engine-driver, guard, or signalman, and we showed experimentally that the idea was perfectly feasible when our absolute block system was employed. This idea has borne fruit, for Professor Fleeming Jenkin, with his usual enthusiasm, was fired with it, and our conjoint ideas have led to what is known as "telpherage." "Telepherage" the Greek scholars among you will no doubt consider better, but in these days of speed and brevity, when the words "ergs," "volts," and "ohms" are tolerated, the abbreviation of "telepherage" to "telpherage" will doubtless be pardoned. We may mention that telpherage experiments on a working scale are on the eve of being tried, so that we hope that "to telpher" will shortly be a common English expression.

For telpherage, and indeed for motor work generally, it became of immense importance to know what horse-power per pound dead weight of motor could be practically obtained, what efficiency could be relied on, and how a motor could be best governed that it was always made to go at the same speed whatever work it was

* A Paper read before the Society of Telegraph Engineers, May 10, 1883.

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doing. We have therefore been engaged on a long series of experiments on motors of different sizes, but before giving an account of the result of these experiments we will consider theoretically the general principles involved in the government of motors, and exhibit one of our motors which is governed without using anything of the nature of a mechanical governor.

GOVERNING.

A motor may be governed to run at the same speed whatever work it may be doing, in one or other of two distinct ways. 1st, the power may be cut off in proportion as the work is cut off; or, 2nd, a brake may be employed to replace the useful load removed, which brake may either waste the excess power or store it up for future use. Hitherto the first method alone has been attempted, viz., that of cutting off the power, and usually with this very serious defect, that instead of the power cut off being directly in proportion to the work cut off, the arrangements have been such that either all power was cut off or none, so that the motion of the motor was spasmodic, just as in an ordinary gas-engine, which suffers from the same defects, that full charge of gas or no charge are the usual only alternatives. A sample of an electro-motor governor of this type, and which may be called a

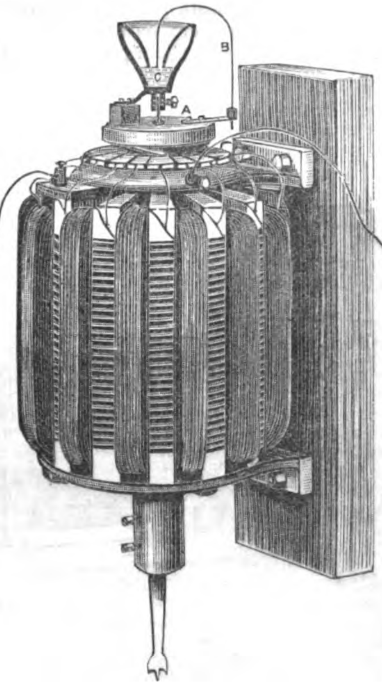

FIG. 4.

"spasmodic governor," is shown (Fig. 4), and consists merely o a rotating mercury cup into which dips a wire, which makes in this case contact with the mercury, and so completes the circuit when the speed is slow, but which, on account of the hyperbolic form assumed by the surface of the mercury as the speed rises, ceases to dip into the mercury at high speeds, and so breaks contact. This governor, you observe, is very erratic in its action, yet it will be found among the modern specifications at the Patent Office.

(TO BE CONTINUED.)

BANQUET TO DR. NORVIN GREEN.

A banquet was given at the Star and Garter Hotel, Richmond, on the 3rd inst., by the Eastern and Eastern Extension Telegraph Companies to Dr. Norvin Green, the President of the Western Union Telegraph Company of America. The chair was taken by John Pender, Esq., M.P., who was supported on the immediate right by Dr. Green, and on the left by Viscount Bury, the other guests forming a distinguished company, including members of both Houses of the Legislature, of all shades of political opinion, and men eminent in the worlds of literature and science. The following gentlemen accepted invitations, and with one or two exceptions they were all present:—The Lord Advocate, Lord Hawke; Sir Thomas Wade, Sir Douglas Forsyth, Sir T. Brassey, M.P.; Sir E. Y. Henderson, Sir C. Forster, M.P.; Sir James Anderson; J. Denison Pender, Esq.; C. W. Earle, Esq.; W. Ford, Esq.; A. Asher, Esq., M.P.; F. Dixon-Hartland, Esq., M.P.; Hon. J. C. Dundas, M.P.; Henry Edwards, Esq., M.P.; Hon. A. de J. Egerton, M.P.; Dr. R. Farquharson, M.P.; Alfred Giles, Esq., M.P.; J. E. Gorst, Esq., M.P.; A. Grant, Esq., M.P.; Michell Henry, Esq., M.P.; P. S. Macliver, Esq., M.P.; R. B. Mackie, Esq., M.P.; Sir J. M'G. Hogg, M.P.; C. J. Monk, Esq., M.P.; C. M. Norwood, Esq., M.P.; J. H. Puleston, Esq., M.P.; Professor Thorold Rogers, M.P.; P. Rylands, Esq., M.P.; W. M. St. Aubyn, Esq., M.P.; Dr. Webster, M.P.; S. Williamson, Esq., M.P.; C. W. Strange, Esq., C.B.; Sir E. Archibald; Maj.-Gen. Beadle; Sir F. Burdett, Bart.; Commander Forsyth; Professor Gordon; Admiral Sir E. A. Inglefield; Professor Fleeming Jenkin; Hon. Ashley Ponsonby; Capt. Shaw; J. H. Bailey, Esq.; Sam Ward, Esq.; C. H. B. Patey, Esq.; W. H. Preece, Esq.; Edward Graves, Esq.; H. C. Fischer, Esq.; Chas. Burt, Esq.; G. C. Bompas, Esq.; F. H. Hill, Esq.; W. H. Mudford, Esq.; John Latey, Esq. (jun.); L. M. Lawson, Esq.; Walter Wood, Esq.; W. T. Madge, Esq.; C. H. W. Biggs, Esq.; W. Batho, Esq.; J. Beaumont, Esq.; D. Bremner, Esq.; A. Brown, Esq.; J. T. Brown, Esq.; T. A. Bullock, Esq.; W. Burman, Esq.; T. O. Chapman, Esq.; F. W. Chesson, Esq.; F. Von Chauvin, Esq.; Latimer Clark, Esq.; Jas. Coates, Esq.; T. M. Collett, Esq.; W. J. Cordner, Esq.; R. M. Cunningham, Esq.; Juland Danvers, Esq.; W. Flux, Esq.; H. C. Forde, Esq.; W. Fowler, Esq.; R. Gilmour, Esq.; John Glover, Esq.; Dr. Goodsall; J. O. Green, Esq.; J. G. Griffiths, Esq.; J. Griffiths, Esq.; W. G. Hall, Esq.; F. S. Harwood, Esq.; G. O. M. Herron, Esq.; F. E. Hesse, Esq.; F. H. Jeune, Esq.; W. C. Johnson, Esq.; Robinson Kendall, Esq.; W. H. Lucy, Esq.; W. MacAndrew, Esq.; J. W. Martin, Esq.; H. W. Maynard, Esq.; T. F. Moulton, Esq.; J. Muirhead, Esq.; C. J. Nicholson, Esq.; Capt. Pattison; Wm. Payton, Esq.; Bennett Pell, Esq.; Capt. Perkins; S. E. Phillips, Esq.; W. G. Probyn, Esq.; A. W. Rixon, Esq.; H. A. C. Saunders, Esq.; E. Squier, Esq.; J. H. Thomas, Esq.; A. H. Thornton, Esq.; E. Tombs, Esq.; F. S. Townend, Esq.; M. C. Wilkinson, Esq.; Maj. W. E. Williams; F. Youle, Esq.; George Draper, Esq.

The CHAIRMAN gave the toasts of "The Queen," and of the "Prince and Princess of Wales and the rest of the Royal Family," which were drunk with the usual enthusiasm. He next proposed the Army and Navy and Reserve Forces, referring to the pride which Englishmen felt in the navy, to the late war and its successful termination, and to the strength which the reserve forces would afford in a time of need.

Sir THOMAS BRASSEY, M.P., replied for the Navy, which he assured them was not in the melancholy description which had recently been described.

Sir J. M'GAREL-HOGG, M.P., answered for the Army; and the Hon. A. de T. EGERTON, M.P., for the Reserve Forces.

The CHAIRMAN then proposed the "Lords and Commons," Lord BURY replying for the House of Lords, and Sir CHAS. FORSTER, M.P. (as the oldest member present), for the House of Commons.

The CHAIRMAN: The next toast I have to propose is that of the health of my friend, Dr. Norvin Green [loud applause]. The last time I paid a visit to the United States, when I made the acquaintance of my honourable friend, I received hospitality which took me by surprise, and I am satisfied that any Englishman going out there with, as the Americans say, a good "record" will find extended to him an amount of hospitality which rarely occurs to us in our travels in any other country. Dr. Green showed me the vast enterprise over which he presides, and in passing over that great continent I was perfectly astonished at the way in which telegraphy was carried on broadcast. I invited Dr. Green to visit this country. He has come here for the first time, and I shall ask him to give us this evening some of the impressions that he has formed of the old country. But before asking him to do this I must tell you something of the company over which Dr. Green has presided for the last few years with so much credit to himself and with so much profit to those immediately interested. Dr. Green is president of the Western Union Telegraph Company of America. The capital of the company is 80,000,000dol. They have got 13,000 stations, 150,000 miles of poles, 425,000 miles of wires on those poles, and they employ a staff of 20,000 people, and Dr. Green at one of the meetings of the company last September stated that 180,000 miles of wire had been added during the last five years, being at the rate of 36,000 miles per annum. That, gentlemen, goes round the globe one and a half times. Last year the number of messages sent over that company's lines amounted to about 40,000,000, not far short of a message for every inhabitant of the United States, man, woman, and child. This tells you something of the institution over which my honoured friend presides, and of the great enterprise of our cousins on the other side of the Atlantic. I should occupy too much time if I went into this matter fully, and I am going to set an example and make a short speech. I think, however, I have given you figures that will afford matter for reflection. I do not believe that the great governing powers of the different countries of the world have the slightest idea of the statement I have put before you this evening as to what the development of telegraphy has been. I do not think they have yet recognised the importance of telegraphy. I shall now leave Dr. Green to speak for himself. I have given him what I believe to be an introduction which he desires into a company of men of all classes of political opinion, and men of high scientific attainments, and I am quite certain that you will properly appreciate the position which my honourable friend occupies, and the importance to the civilised world of the enterprise over which he presides.

Dr. GREEN, who was received with loud and continued applause, said: Mr. Chairman, my Lords, and Gentlemen—You overwhelm me, not only with the distinguished honour that you have conferred upon me, but with the very extravagantly complimentary manner in which it has been proposed. It would require a public speaker of far more eloquence and experience than myself to acknowledge in befitting terms this distinguished honour—the continued hospitality which has been extended to me during my stay in this country, and the very complimentary manner in which I have been presented to the public generally. To you, Mr. Pender, I am most indebted. Before I had put my foot on English soil your hospitable arm reached me in the harbour of Queenstown, and during my entire sojourn in this country your kindness has never flagged. You have continued to present me to your friends in a manner that I feel I have not deserved. To the telegraphic fraternity throughout the country I am also indebted for the kindness and consideration which I have received, but which I have no right to. I have found your people a jovial, sociable, and clever people, reminding me of the reply of the man Friday in one of Lydia Thompson's very clever extravaganzas of *Robinson Crusoe*. When she had taught the man she had captured in the desert some of the rudiments of civilisation, she told him that the time had come for him to choose a profession or avocation in life, and proceeded to point out to him the advantages of the law, of medicine, of the pulpit, the army, and the navy, in the usual pedantic harangues as to each. After thoughtful

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reflection the man answered, "Well, I believe I would rather be an Englishman if there is a vacancy" [laughter]. Your kindness has made me think very much after the manner of Friday. Mr. Pender has asked me to give you some of the impressions I have formed of your country. Since I met many of you on the occasion of your kindly receiving me at dinner at Greenwich, I have had three months' time in which to look round and study your country and its institutions, its strength and power. As to your country, it presents a culture and a beauty that only centuries can attain. Your towns and villages present an industry, comfort, and thrift truly remarkable, and with your great metropolis, the great financial centre of the civilised world, go to make up merry old England, our mother country [applause]. But these together are but small factors in your strength and power. Nor is it because your ships float upon every sea and whiten with their sails every ocean, nor yet that your colonies dot the whole face of the habitable globe, so that the sun never sets on the British dominions. No; the great strength and power of your country as a nation rests on the latent wealth of your citizens. Go into one of your great houses in the City, with its hundred business offices, and note the signs you see there. They mark the fact that your capital and intelligence control corporations of every industrial character in every part of the habitable globe. Further than this, your capital is invested to such an extent in the bonds and securities of states, cities, railroads, and other corporations throughout the civilised world, that there is not, for instance, in my country a single state, scarcely a county, some part of whose domain is not mortgaged to British bondholders. You hold two thousand million dollars of our securities, and we pay you interest at the rate of a hundred and twenty million dollars per annum. The greater part of that we obtain by the balance of trade in our favour. If you hold that much of our securities, you must hold three or four times as much more in the rest of the countries of the earth. I am informed that it has been ascertained in the department of the Exchequer of your Government that the income of your citizens from these investments is a hundred and sixty millions sterling per annum—800,000,000 dollars. Now, suppose one-half of that is spent in living by your citizens who have no other income (and I have had occasion to learn that your people know how to live handsomely), there still remains 400,000,000 for re-investment. I am forced, therefore, to the conclusion that your strength and power are growing, and that they have that character about them which must be controlling. But it does not follow from all this that our people have done a bad business notwithstanding [laughter]. We are a young and growing country, with mines of wealth undeveloped, in our rich agricultural lands, and in our minerals. Their value has been greatly increased by means of these loans—by the railroads constructed with them. Many of our citizens have grown rich on money borrowed at a very high rate of interest. Many of our railroads are paying you not only 6 per cent. and 7 per cent. interest on those heavy loans, but paying 8 per cent. dividend besides on shares and capital stock. There may be, and probably are, individual exceptions, but as a general rule our country has profited by creating these liabilities. We are marching on to wealth and strength, and the time will come when we shall no longer be a debtor nation, but like yourselves, a creditor of other states. We are a fast people [applause]. We move on. You are slow and thoughtful, never in a hurry. I remember reading a newspaper recipe for kissing a pretty girl. It was rather a dawdling process, beginning by resting the head on the left arm and so forth, but there was everywhere interjected the exclamation, "Don't be in a hurry." Now, an Englishman is never in a hurry; but that would not do on our side. Things move on with such rapidity with us that if one is not in a hurry he will simply get left behind, that is all. To those of us who have passed our three score the allusion of the chairman to the progress during the reign of your present Queen has a forcible effect. We have had the good fortune to live in an age when there has been more advance and progress in practical arts, in navigation, and in appliances for saving labour, for annihilating time and space than ever took place in five times as many years in any previous period of the history of the world. Within that period the steam engine—the iron horse—has been harnessed to every conceivable form of industry, saving the labour of hundreds of horses, and a still greater number of men in every town and village of your country. I need not refer to the numerous inventions for saving labour and time, of which the steam engine is the leading principle, having revolutionised navigation, and the carrying trade overland, accomplishing in days what before took weeks, but I beg to remind you that our country west of the great water has contributed her share of them [cheers]. Among the inventions she has given to the world, I may enumerate the mower, the reaper, and that modern blessing of the domestic household, the sewing machine. But I am naturally proud that she also gave you the electric telegraph, and, more recently, the telephone and the electric light. It is scarcely forty years since the first electric wire was erected and the first telegraph message sent. What a revolution has been accomplished within forty years, most of it, I ought to say, within the last fifteen or seventeen years, since the first transatlantic cable was laid [cheers]. The people were slow to believe in it, still slower to appreciate and patronise it; but now there is scarcely a member of the community that does not have to use it. Within the last fifteen years the companies which do me this honour to night have acquired, and are now operating 36,000 miles of cable, and that means going once and a half round the world, and the company which I represent has, within that period, increased its plant five-fold, from 75,000 miles of wire to 425,000, having now sufficient wire to encircle the globe seventeen times [applause]. Mr. Pender once kindly told you something of our system penetrating the forests of the far West. We have gone in advance of civilisation, and the sign of progress in those parts is the little blue sign of the Western Union Telegraph Company, which combines communication with all the world. It was from one such office as that that Mr. Pender sent his message to Lord Wolseley, and received a reply announcing the victory in Egypt. Away out on the North Pacific Railroad, in advance even of settlements, it is the same everywhere. We move on so rapidly that we build our railroads, and settle the country afterwards. [The Chairman: That is quite true.] Now I beg to remark just here, for the benefit of our friends who insist that our capital stock is extremely "watered"—that, as I have told you, within the last seventeen years we have increased our plant more than five-fold, and we have increased the capital less than two-fold. Then we had 75,000 miles of wire, and our capital was only 41,000,000 dollars, whereas now with 425,000 miles of wire the capital is 80,000,000 dollars. Then its market value on the exchange was 40 to 60 per cent. It is easy to see that it is cheaper to pay par now than it was then to pay 40 per cent. But for the benefit of the telegraph gentlemen present I beg to make the prediction that the telegraph is yet in its infancy. I believe it will make more advances in the next five years than it has in the last five years. Although it has accomplished much there are many uses of the telegraph yet to come. As an interest-saving method it must come into general use for bankers' drafts. The interest on a £10,000 draft at the American rate of 6 per cent. is about £1 4s. per day. It is not safe to expect to remit a draft from New York to London in less than fifteen days, which would much more certainly come by telegraph in a code message in one day. So that for the expense of £1 for telegraphing, £18 in interest might be saved. There must also be brought about closer commercial and speculating relations between your great metropolis and ours. The interest of dealers and jobbers necessitates a uniformity of the hours of exchange, so that the two exchanges may be uniform, for two hours at least during the business part of the day. That once accomplished and connected by more than one cable wire, you will find an immense increase of telegraph business. But there are new industries, new items of commerce, new streams of trade, that are adopting the telegraph for universal use and its growth and increase must be immense. I presume we are handling in the city of New York over 80,000 messages per day. We have got, as you know, for certain periods, very much beyond that. Throughout the country we are handling about 200,000. But, gentlemen, and Mr. Pender, the time has come for me to bid you a grateful farewell. I have enjoyed much of your hospitality. I have been invited to drink to Her Majesty the Queen, which I have done in hearty good will, for, if you must have a Queen, I am sure you have one that every Englishman must love, honoured and respected as she is all over the world, not only for her wise and prudent government and the exalted and exemplary character of her Court, but from her innate goodness, nobility, and benevolence [applause]. But our criticism on your form of government is not that you have a sovereign, but that you have only one. In our country we have fifty millions. The fact may not be appreciated, but we have no one below the grade of sovereign. But with forms of government so dissimilar, it is rather remarkable that there should be such a great similarity in the freedom of the citizens and in the aim and object of our general legislation—to insure the protection of life and the promotion of civil and religious liberty. In those high aims of government, England and America and all the Anglo-speaking peoples in the earth march hand in hand. May they continue so to advance! [Applause.] Then English shall become the language of every nation in the world, and those elementary principles of the English-speaking people be everywhere embraced [loud applause].

Lord BURY next proposed success to the Eastern and Eastern Extension Telegraph Companies, and for the information of the guests referred to the numerous ramifications of the telegraph systems worked by these companies.

Mr. PENDER, in reply, said: My Lords and Gentleman—The eloquent speeches of my friend Dr. Green and my right hon. friend Lord Bury have taken from me all the matter that I might have brought with me this evening. Fortunately, however, time does not permit me to say much, but I may say this that no great work, such as the extension of submarine telegraphy, could have been done by any one man. I have had associated with me men of great enterprise and ability, who have followed me throughout and placed the greatest confidence in the work that has been done. I can say more than that (and I think very few chairmen could say it), that in the whole course of my connection with this telegraph system connected with every part of the civilised world, I have never had one division at any Board. This shows, I think, clearly that we have been, at all events, a united body. So far as the Eastern Telegraph Company is concerned, it is not much more than fifteen years since it was established. At that time there were something like 2,000 miles of cable in operation among us. There are now 90,000 miles of cable, and the capital invested in submarine telegraphy is something like 32 millions sterling. We have heard a great deal lately about a certain enterprise, which has been considered the wonder of the world. I give the greatest honour to M. de Lesseps, who conceived and carried out successfully the Suez Canal, but this great work of submarine telegraphy was a highly scientific work, and so speculative that in its early days it was almost impossible to get a man to put a pound into it; and but for such men as the father of Sir Thos. Brassey, men who could look a little into the future, and would put their hands into their pockets, it would have been impossible to establish confidence in submarine telegraphy. Now it has been carried out, and I have no hesitation in saying that, looking to the fact that a great portion of this great empire (35 millions of people are on this side, but in our Indian empire alone there are 250 millions, while in our colonies there are something like 50 millions) is in the East, the progress of this empire depends upon the future of those countries. China is about to be developed, and within the last few days I have had a most encouraging telegram from that country. I may not live long enough to see it, but the Chinese are a shrewd people, and the moment they see the advantage of railways and telegraphy there is no doubt that they will be established everywhere over that country with its 350,000,000 of people. Why, there is a great future for England to be looked to in that fact alone! People tell me of the decay of England. Why, England is the workshop of the world—and something more, she is the great banking institution of the world; and what with her telegraphic enterprise, and her shipping enterprise, and the genius of her people, I have no fear but we shall hold up our heads for many long years to come, and there will be no greater or nobler race then when we find our friends on the other side of the Atlantic competing with us. I believe in competition, and I believe that when the two English speaking peoples begin to compete with each other they will take possession of the trade of the world. I believe that submarine telegraphy has so far played a most important part, but that it has a far more important one yet to play. I tell you there is no great transaction in commerce that is not begun and concluded by the telegraph. Telegraphy is the pioneer of commerce, and it will become an increasing necessity in future in all the commercial transactions of the world. I say more, it is not only useful in commerce, but useful in war. I was told by the most distinguished general who led our army so successfully in Egypt, that had it not been for the cable that was laid down by the Eastern Telegraph Company from Alexandria to Port Said, it would have been impossible to complete the war in so short a period

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as that in which it was done. When you consider what the expense of war is, you will see what an enormous benefit the Eastern Company conferred upon the Government in carrying on that work, for which they did not receive in money a shilling towards the expense. Gentlemen, I have to thank you for the honour you have done me and my colleagues, and I would only assure you in conclusion that our meeting here this evening has been a source of great pleasure to us.

Mr. NORWOOD, M.P., prosposed the "Health of the Chairman," who he said belonged to a class of men who performed a very great service not only to this country but to the world at large. Men of science might discover in their laboratories or in Nature some great secret which was able to revolutionise society, but such men had no great business knowledge, and it required the clear-headed man of business to influence the money market in favour of and give practical effect to those inventions, otherwise they would be left unused in the hands of the discoverer. It was to men like Mr. Pender that they were indebted for carrying them into practical effect.

The toast having been drunk with great cordiality,

The CHAIRMAN briefly replied, remarking that he hoped they would have an opportunity at no distant day of meeting again so many distinguished gentlemen.

Sir JAMES ANDERSON, in a happy speech, then proposed "The Guests," which was responded to by

Mr. BAILY, from America, in a few well-chosen and humorous sentences.

The proceedings shortly afterwards terminated.

ANGLO-AMERICAN TELEGRAPH COMPANY.

The half-yearly general meeting of the shareholders of this Company was held on Friday, the 3rd inst., at the Cannon-street Hotel, under the presidency of the Marquis of Tweeddale.

The SECRATARY having read the notice convening the meeting, and the minutes of the previous meeting, which were confirmed,

The CHAIRMAN said: Before asking you to adopt the report and accounts, which I presume you will take as read, I shall occupy your time for a very few minutes, and first, with your permission, I will refer to the absence of our respected chairman, Viscount Monck. He has returned from abroad with his health very much improved, and I hope before long he will resume his place at our councils. Gentlemen, in referring to the report, I am glad to be able to allude to several satisfactory features in it. In the first place, the traffic receipts have exceeded those of the corresponding half of 1882 by the considerable figure of £36,333. It is quite true this is due to the resumption of the 2s. tariff, but that must satisfy every one of the very great importance of coming to a friendly understanding with those competitors that rendered a reduction of the tariff necessary. The next satisfactory feature is on the expenditure side of the accounts. From that you will perceive that the expenses of the last six months show a reduction of very nearly £4,000 (the exact figures are £3,976) as compared with the corresponding six months of the previous year, and when the expenses are contrasted with those of the year preceding, 1881, you find the reduction reaches considerably over £7,000. I hope this will be considered as affording evidence of a desire, which has often been expressed by those representing the Board, to reduce the expenses of the Company to a limit as low as possible consistent with its efficiency. Well now, the third satisfactory feature is that your cables are in excellent condition. This means more than appears at first sight, because the great difficulty of cable companies is the immense sums which occasionally have to be spent in repairing the cables. I am happy to say that this time that expenditure has been very small, and, as far as we can judge, there is no prospect of any large expenditure under that head being necessary in the immediate future. The report refers to the establishment of a separate office in New York. This was demanded by the telegraphing public of America, who required that there should be more than one office for the reception and delivery of messages, and your Company agreed to bear a portion of what appeared to them a very necessary expenditure in the interest of the Company. I am glad to say that this independent office has worked with entire success, and has been attended with considerable advantage to us all. Now, gentlemen, though I have been dealing with certain satisfactory features, I will not for a moment disguise that the general result, as shown by the dividend, is not altogether what we could desire on this side of the table, either as shareholders or directors. At the same time, the causes of that are very apparent. In the first place, there has been, and still is, I am sorry to say, great dulness and slackness in trade throughout, I believe, the whole world. This is reflected in our receipts, and that sort of increase which we might have called the normal increase up to this last year has almost entirely, I think, disappeared. But a far more important cause is that we have to share the gross traffic with additional partners. The gross traffic has now to be distributed over eight cables. As you are aware, this Company enjoys no monopoly of the Atlantic Ocean, and cables can be laid by any person between Europe and America, and, of course, England. Therefore, it is impossible for us on this side to be blamed for this very potent cause, namely, the increase of cables which take the traffic away from us. We are equally helpless with regard to the course of trade. In the future, however, what have we to look to? Well, we must rely on what is probable, that trade will recover, and reflect its recovery in increased receipts. In the second place, we may hope that the laying of cables will cease. Certainly those that have been laid lately have not, as far as I can ascertain, proved profitable to the persons laying them. Thirdly, and most important of all, I think the day may come when it will not be necessary to lay such very large sums apart to our renewal fund. This question has been referred to by an honourable proprietor, who takes an interest in this Company and is a considerable shareholder in it; but I need hardly tell you that the directors have not altered their opinion in any way whatever as to the importance of the renewal fund, recognising at the same time that there is a period when it will not be necessary to put so much to it as we consider desirable now. I may say that, taking for instance what is done by the Direct Company, you find that that Company has put by a reserve fund amounting to a sum which would cause ours, if it were the same in proportion, to be nearly equal to £1,200,000. That is to say, if we considered it necessary to have the same amount of renewal fund for our four cables as they think necessary to have for their one (and very experienced persons have the administration of that company), we should have to have the amount I have mentioned. I am not going to say what sum the Board think that the renewal fund should reach before the transfer of £150,000 a year is reduced, but I hope it will be less than £1,200,000. There is only one other point to refer to—the announcement in the ninth paragraph in the report, in which it is stated that your directors have agreed to pay (and have now indeed paid) a sum of £4,500 to Mr. Harding for services rendered by him in 1880 in connection with the arrangement which was entered into with the French Company. I daresay you will remember that when the French Company was established a war of rates took place, which led to a lamentable falling off in the receipts of the Anglo-American Company. Negotiations were entered into without loss of time to make an arrangement on an equitable basis that would reduce those rates. These negotiations took a very long time, and those employed in connection with them met with considerable difficulty and obstacles, but they were eventually removed, and in a large degree through the instrumentality of Mr. Harding, a gentleman whose long residence in Paris, and his acquaintance with the directors on both sides of the water, made him a fitting person to conduct such negotiations. The arrangement was very satisfactory, and has worked with complete success ever since. Mr. Harding, however, placed a very high, I might say almost exaggerated value, upon the services which he rendered. Your Board were not willing to recognise that exaggerated value, but after careful and long consideration of the matter they arrived at the conclusion that the sum of £4,500 would be a fair remuneration for the services which Mr. Harding undoubtedly rendered. I may add that the Direct Company took exactly the same view, and paid a certain sum in addition corresponding to the amount that we paid. With regard to this matter I have only to say that those gentlemen who are acquainted with the members of this Board will feel perfectly assured that not a penny has been spent more than they consider proper and in the interest of the Company. With these observations I will now move the following resolution:—"That the report of the directors and the accompanying statement of accounts to the 30th June, 1883, submitted to this meeting be and the same are hereby approved and adopted."

Sir DANIEL GOOCH, Bart., M.P., seconded the motion.

Captain TROTTER thought that the sum proposed to be paid to Mr. Harding was large, and the shareholders had no knowledge of the circumstances in which it had been voted. The delay in settling the claim seemed so extraordinary, that it appeared to him to be entirely a matter of confidence in the Board for the shareholders to assent to the course proposed. He thought the amount was very excessive, and it was a very unsatisfactory charge for them to be called on to pay. He had confidence in the directors, but he had no faith in the management of the Company, with their shares at 50 per cent. discount, and he thought that the policy which had been pursued had not been wise or politic in the interests of the shareholders.

Mr. JOHN NEWTON also condemned the payment to Mr. Harding. The amount had been paid, but still it occurred to him whether, if some independent shareholder tried the question, the directors would not be compelled to refund it out of their own pockets. In saying that, he was quite aware that the Articles of Association gave them very extraordinary powers, but he doubted whether they gave them powers to give away such large sums to any individual for simply bringing directors together. He wished to know the nature of the work done by Mr. Harding and the length of time occupied, as the amount received by that gentleman from this Company and the Direct Company must simply be enormous. He condemned the way in which those who were connected with rival companies were treated by existing companies, and contended that such demands as these were inducements to promote rival companies. Such people should be fought to the death, and if that course were followed he contended that very few competing companies would be floated. If the amount had not been paid he would have moved an amendment to the report expressing the opinion of the meeting that such payment was uncalled for and unnecessary, but as the money had been paid he supposed it was no use crying over spilt milk.

The CHAIRMAN: Your Board do what they can in the interests of your Company, and I think you may accept my assurance that they do their very best, and have done so in this particular case. The matter was a very difficult one, involving a great deal of anxious negotiation, and your Board, it appeared to me, was justified in making use of any person who was likely to bring the matter to a satisfactory issue. We were receiving at that time about £980 a day. That was the volume of our traffic, but the moment this arrangement came into force our receipts rose to £2,200 a day. I think under these circumstances the Board was justified in making use of such instruments for the purpose they had in view as they thought best in your interests. The cause of the delay which has taken place in arriving at a settlement of the amount to be paid was that Mr. Harding opened his mouth very wide, and we were determined not to accept the value that he set on his services, and we resolved to pay instead only what we considered the fair value. It may appear a liberal sum, but I do not think it is more than he was entitled to. As to his having anything to do in promoting any rival schemes, I feel sure that he had nothing to do with getting up the French Company, and I never heard of him in connection with any other rival company. There is nothing to conceal about Mr. Harding, who was useful for our purpose. If any similar circumstances arise to those which rendered Mr. Harding's services necessary, we must again use the best instruments we can find, and I hope we shall do so with as good results.

Mr. SEELEY inquired what was the amount of interest received on the sums invested by the Company, and urged the directors as far as possible to reduce the expenditure, which he thought was very large, and, in his opinion, some of the salaries ought to be reduced. The shareholders were now receiving a dividend at the rate of only 3 per cent., and he was afraid it would not be larger. For years past the Company had been retrograding, and he did not see much hope of it getting into a better position. He therefore thought economies necessary in every possible way, for the dividend was exceedingly small, having regard to the nature of the investment.

Mr. GRIFFITH also contended that the amount paid to Mr. Harding was rather large, but still the Company authorised the directors in the matter,

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and he thought the Company was responsible for the payment. They were approaching a period when the reserve fund might be supposed to have reached its proper limit. He was appalled when he heard the chairman mention £1,200,000. The sum of £500,000 seemed to him (the speaker) a very satisfactory amount with which they would be able to go into the market and buy a cable, and the credit of the Company was so satisfactory that they could obtain money at 4 per cent. The Eastern Company were doing that, and if that company could do so the Anglo Company could, and therefore he did not think the shareholders should be asked to continue making this large provision for the renewal fund. If they had not the power to raise money on debentures it was very easy to obtain powers. He recognised the necessity of their being able to go into the market and buy another cable when circumstances required it, but he would prefer some portion of the present large renewal fund being distributed by way of dividend. He thought a portion of the amount might be used for meeting such claims as those of Mr. Harding and in buying up their own stock. He was quite sure that the proprietors would welcome Lord Monck back.

Mr. ASTON, *àpropos* of the chairman's remarks respecting the renewal fund, thought that with £500,000 in hand the annual transfer to the fund might be limited to £50,000 a year. He also thought that if they had not the power to borrow money, or to buy up their own stock, they ought to obtain such powers.

Mr. SMITH considered that the report was of a very satisfactory nature. He did not hear anything about any new cables being projected, and that he regarded as a very encouraging feature. There had, however, been a rumour on the Stock Exchange to the effect that a new cable was projected, and that the existing companies were going to have opposition, but as the noble chairman had said nothing about it, he (the speaker) assumed that the rumour was simply a trick of the Stock Exchange to depreciate the shares. He thought that instead of laying by £150,000 a year to the renewal fund, only £100,000 should be set apart for that purpose (that, however, was only a suggestion), and that £50,000 should be put to a defence, but not a defiance fund. If any other company wished to start on their own ground he would let them do so, but he urged that there should be a certain fund in existence in this Company which the Board might come upon at any time to equalise the dividends. [A Voice: That is the object of the reserve fund.] No; he thought the reserve fund was for the renewal of the cables. The Anglo Company, unlike the Direct Company, had not the power to use the amount which had been set aside to renewal fund for any other purpose. With regard to the payment to Mr. Harding he believed that in paying that amount the directors had used a wise discretion. He knew that the French Company would not hear of anything less than 18 per cent. of the gross traffic, and the Anglo Company offered to give them 16¼ or 16½ per cent., but through Mr. Harding's instrumentality the French Company were eventually induced to take 16 per cent. He did not think that under the circumstances they could find much fault with Mr. Harding, though he would not encourage such people. Still, the very first week the settlement was arrived at they cleared the amount which was paid to Mr. Harding.

Mr. REEFER expressed his readiness to second the resolution to put aside £100,000 a year to the renewal fund.

Mr. FORD had not intended to make any remarks, but in view of what had been said concerning the payment to Mr. Harding he thought, as representing the largest shareholder in the Company (the shareholding interest of over a million of their stock), he would fail in his duty as a director of a company associated with the Anglo, which, like the Anglo, had gone through the ordeal of competition created by the French cable, if he did not state, as he was able to do of his own knowledge, that the directors of the Anglo Company had done everything they could, morally and legally, in company with the associated companies to resist the exaggerated claims of Mr. Harding. That resistance had occupied a considerable part of the time (and a considerable part of his time personally), and they came to the conclusion, with the best advice that they could get, that they must acknowledge the services which had been rendered by Mr. Harding, and pay for them, and that if they failed to do so they would in a court of law probably have to spend in legal expenses more than they had done in satisfying Mr. Harding's claim. Having himself taken a somewhat important part in the negotiation which brought about the arrangement with the Pouyer-Quertier Company he could testify to the very valuable services rendered by Mr. Harding, and he ventured to say that if those services had not been given as they were, and in quarters where they were so influential, they would have continued to lose at the rate of over a quarter of a million of money in diminished traffic.

Mr. VEARES observed that after the remarks of Mr. Ford they must feel satisfied with the justice of the payment. Speaking as one of the deferred shareholders, he urged the directors to do their utmost to increase the amount distributed amongst that long suffering body.

The CHAIRMAN: We all sympathise with the last speaker, because whatever affects beneficially a deferred shareholder will, of course, benefit the ordinary shareholders, and I sincerely trust that at the next meeting we may be able to give him a better account of his deferred property. As to Mr. Seeley's remarks, I think I gave the most ample evidence on the part of the administration of our desire to reduce the expenses as low as possible. They have been reduced no less than £7,000, comparing the past six months with the same period of 1881, and £4,000 as compared with 1882. As to Mr. Griffith's remarks, that authority should have been taken as to this affair of Mr. Harding, in the case of the Direct Company authority was, I believe, taken to make an arrangement. Your Board, however, did not proceed in the same way, thinking that it would prove more satisfactory to the shareholders that we should settle the matter, and then bring the payment before you. As to the question of borrowing money, we are in the habit of congratulating ourselves that we have no debentures [hear, hear], but the question raised by Mr. Griffith will have the full attention of the Board. The Articles of Association enable us to raise money by debentures, and if it is considered desirable in the interests of the shareholders that money should be raised in that manner at any time it would be done. As to buying up our stock my friend, as a lawyer, must know that it is unlawful.

Mr. ASTON: You could do it by altering your Articles of Association.

The CHAIRMAN: If we can do it, and it is desirable to do it, the matter shall be seen to. Mr. Smith made a very valuable suggestion with regard to the renewal fund, namely, that instead of putting £150,000 aside to that fund the amount should be limited to £100,000, and that £50,000 should be put to another fund the object of which would be to equalise the dividend and other matters of that sort. This is a very valuable suggestion, which will be brought before the Board and have full consideration, and the result will make itself known to you at the next meeting. In regard to Mr. Aston's motion, I only want before it is put in the form of an amendment (as I suppose it will be) to mention these facts. The Anglo-American Company has four cables, and its reserve fund is £490,000. The Direct Company has one cable, and they have already £315,000, and therefore the reserve fund of the Direct Company, which has only one cable, as I have said, is very nearly the same as ours, and we have four cables. With every desire to meet the wishes of hon. shareholders, and especially the deferred shareholders, I think it must be clear to you that the Board could never consent to a policy which would so far depart from what they consider dictated by the most ordinary prudence in dealing with this matter. According to the calculation of the Direct Company we ought, as I have said, to have a reserve fund of £1,200,000. I do not mean to say that your Board are committed to any such policy, but still it is quite clear that in the next six months it is impossible that any serious diminution can be made in the amount of money which we think desirable in the interests of the Company to place to the reserve fund. With regard to the interest on the investments of our reserve fund, the amount invested in 1882 was £340,667, and that amount yielded interest at the rate of 3½ per cent. The investments are in the very best securities.

Mr. WEAVER: They are all set out in the report.

Mr. ASTON said that he would leave his proposition in the hands of the Board and the meeting, but he must say that the chairman had said nothing to alter his opinion. He thought that £600,000 would buy one cable, and as to the chairman's remark about the renewal funds of the Anglo and the Direct Companies, it must be borne in mind that the Direct Company had only one cable, which rendered their position less secure than that of the Anglo-American Company, which had four cables. He suggested that the sum which the directors thought the reserve fund should reach should be mentioned by the chairman.

The CHAIRMAN: I think I did my best to point out to you that the fund was not sufficiently large to have made it a question of consideration with us. We have not yet reached a sum which would be necessary for replacing even one of our cables.

Mr. ASTON then withdrew his motion.

Mr. SMITH reminded the chairman that he had given no reply to his (Mr. Smith's) question as to whether any new cable was projected.

The CHAIRMAN: We have no official information on the subject.

The report was then unanimously adopted, and on the motion of Mr. ASTON, a vote of thanks was passed to the chairman and the directors, and the meeting separated.

THE NATIONAL TELEPHONE COMPANY (LIMITED).

The third annual ordinary general meeting of this Company was held at the offices, 11, Queen Victoria-street, E.C., on the 9th inst., under the presidency of Colonel R. Raynsford Jackson.

The SECRETARY (Mr. Wm. B. Campbell) having read the notice convening the meeting,

The CHAIRMAN said: Gentlemen, the directors' report and balance-sheet has been in the hands of most of you, in fact of all the shareholders for some days. I wish to know whether you desire them read, or will you take them as read? [A Voice: "Take them as read."] The report and the balance-sheet themselves sufficiently explain the position of the Company, and I shall not occupy your time further than to refer to one or two salient features. First of all you will find that whereas we carried forward a balance after paying the dividend last year of £144 9s. 8d., we carry forward this year £2,530 16s. 6d., having paid the dividend upon a much larger capital. The next point of importance is that there has been a considerable increase in the gross revenue of the Company. The gross revenue allocated to the year ending 30th June last is £34,562, against £19,243 allocated to the preceding year, and the amount carried forward to next year's revenue is £24,089 10s. 6d., as compared with £15,643 last year. Those are the only points to which I think, as regards the balance-sheet, it is necessary to call your attention. At our meeting last year I referred to our position with relation to the Post Office, and to the character of our relations with the Postmaster-General and the permanent staff of that department. I pointed out that those relations were extremely satisfactory, and that there was every disposition on the part of the department to relax the pressure of the restrictions imposed upon us by the Postmaster-General under the powers given to him by the Telegraph Acts, and I have now further to state that the same disposition has been indicated by several important matters. In the Midland district we had the Postmaster-General's license for a small area of of one mile and a half round of each five towns, and it was found almost impossible to establish with those small areas, and in those small towns, telephonic exchanges which could be worked satisfactorily to the interests of the Company. I made application to the Postmaster-General to give two larger areas instead, one area including three of those districts, and the other area the other two. At first there was great indisposition on the part of the Post Office to make that concession. It was refused, in fact, once or twice, but as circumstances arose tending to show that it was to the advantage of the public as well to the Telephone Company that this concession should be granted, on further representation the Postmaster-General made the concession, and we now therefore, instead of having five small insignificant areas, have two large areas of considerable value, within which we are enabled to connect three towns of some importance in the one area and two towns in the other by our own wires without calling in the assistance of the Postmaster-General. I also told you last year that we had lost heavily by our trunk arrangement with the Postmaster-General. I described its character, and you will see by the balance-sheet that during last year we have also lost by it. I held out to you the expectation that the trunk agreement would be modified, and that we should be placed in a better position to carry on the business of the Company in the future than we had been in the past so far as

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the connection between distant centres is concerned, and I am happy to inform you that a very important concession has been made by the Postmaster-General in that particular. Instead of being obliged to take a trunk wire, paying for eight subscribers, and not being allowed to put on more subscribers, and losing the difference if we did not secure eight subscribers, the Postmaster-General has agreed to grant us trunk wires at a charge of £10 per mile for the double wire, and to allow us to put on as many subscribers as we can give a satisfactory service to, accounting to the Postmaster-General for half of the receipts of the above original payment. I believe that will greatly facilitate our trunk business, and enable us to give a more satisfactory service to the public, of course at the same time developing our exchange business. I referred last year also to our relations with the United Company, from whom we hold our licenses. I told you that those relations were of a very satisfactory character, and I am happy to tell you now that they continue to be so, and it is a matter of satisfaction I think to us all that the United Company has succeeded in vindicating its patents, and in checking to a very considerable extent, if not entirely, those attempts at infringement which tend to injure its business and that of the companies holding licenses from it. I also referred last year to various other matters in which we are interested. But I did not dwell upon one of importance—that is the position in which we stand as to municipalities. It has been the endeavour of this Company, whenever introducing the telephone into any new town, to make satisfactory arrangements with the municipality and to put our relations with them on such a footing as would secure to us the support rather than the hostility of the governing authorities of the town to which we extended our system, and all round our relations with the municipalities are as satisfactory as they could well be. This being the case, we are on all sides and over the whole area of our districts upon a satisfactory footing with all those with whom we come into contact, and one consequence of that has been the extension of our business, and the fact that it is now expanding at a very considerable pace, and that our gross revenue is increasing at the rate of about £1,500 a month. During the months of April, May, and June the increase was £5,000, and I am anticipating a more considerable increase during the current year, and we shall carry forward next year a very much larger balance than we have done in the past year. I think, therefore, you will agree with me that the position of the Company is such as to entitle it to the confidence of the shareholders, and I trust the service it gives entitles it also to the confidence of the public. I beg to move that the report and accounts be passed.

The VICE-CHAIRMAN (Mr. John P. Bigelow): I second the motion.

The CHAIRMAN: Does any gentlemen wish to ask any question before I put it to the meeting?

No one rising to address the meeting, the chairman put the resolution in the usual way, and declared it carried unanimously. Continuing, he announced that the retiring directors were Messrs. William Hardwicke Bradbury, William Lowson, and Samuel de la Grange Williams; and these gentlemen were duly re-elected, as were also the auditors, Messrs. Quilter, Ball, and Co.

The meeting then closed with a vote of thanks to the chairman.

CUBA SUBMARINE TELEGRAPH COMPANY.

Report of the directors for the half year ending 30th June, 1883, to be presented at the twenty-fourth ordinary general meeting of shareholders to be held on the 15th day of August, 1883:—The directors beg to submit, duly audited, the balance-sheet and accounts for the half year ended 30th June last, from which it will be seen that the gross receipts, including the balance brought from last account, amount to £23,173 3s. 7d., and the gross expenditure to £6,445 7s. 3d., leaving a sum of £16,727 16s. 4d. to the credit of revenue account. Of this, the sum of £3,262 10s. has been placed to the reserve fund, increasing that fund to £54,000. After providing for the preference dividend, a balance of £10,465 6s. 4d. remains, out of which the directors recommend the payment of a dividend on the ordinary shares at the rate of 9 per cent. per annum, free of income-tax, which will absorb £7,200, and leave £3,265 6s. 4d. to be carried forward to the current half year's account. The cables are at present in good working order, with the exception of the 1875 Cienfuegos-Santiago one, referred to in the last report as faulty. Operations were commenced for the repair of this cable, in the course of which it became apparent that a complete renewal of the shore ends would be necessary in order to restore the cable to a reliable working condition. New cable has been shipped for this purpose, on the arrival of which, the Company's engineer, Mr. Keith, will proceed with the work. Three harbour lengths, viz., one at Santiago, which was accidentally broken by a ship's anchor in February, and two at Cienfuegos, which gave way in March and again last month, have been repaired. The decision in favour of the Company, in the suit instituted against the Spanish Government at Havana, for a return of the tax erroneously levied on the Havana-Santiago business, and which was appealed against by the Havana authorities, has been confirmed by the Madrid Courts, and the amount ordered to be repaid. The Company's manager has therefore been instructed to apply to the Cuban Government for payment. The director who retires from the board at this time is Mr. Joaquin de Mancha who, being eligible, offers himself for re-election. Mr. Thomas Greenwood, the auditor, also retires, and offers himself for re-election.

TRAFFIC RECEIPTS FOR JULY, 1883.

COMPANIES.	July, 1883.	July, 1882.	Incrse.	Decrs.
Anglo-American Telegraph Company	—	—	—	—
Brazilian Submarine Company	—	—	—	—
Cuba Submarine Company	2,700	2,921	—	221
Direct Spanish Telegraph Company	—	—	—	—
Direct United States Cable Company	—	—	—	—
Eastern Telegraph Company	—	—	—	—
Eastern Extension Telegraph Company	36,177	30,070	6,107	—
Great Northern Telegraph Company	22,200	—	—	—
Submarine Telegraph Company	—	—	—	—

COMPANIES' SHARE LIST.

TELEGRAPHS.

COMPANIES.	CLOSING PRICES AUG. 8.		BUSINESS DONE WEEK ENDING AUG. 8. Highest.	Lowest.
Anglo American	48,	48½	48¾	48
Do. Preferred	79½,	79¾	80½	78¾
Do. Deferred	17½,	18	17¾	17½
Brazil Submarine	11¾,	12	11 15-16	¾
Cuba	11,	11½	11¾	—
Do. Preference	17¾,	18¼	—	—
Direct Spanish	5¼,	5¾	—	—
Do. Preference	15¾,	16½	—	—
Direct United States Cable	12¼,	12½	12½	12⅜
Eastern Telegraph	10 11-16,	10 13-16	10⅞	10⅝
Do. 6 per Cent. Preference	12⅝,	12⅞	12⅝	12 11-16
Do. 5 per Cent. Debentures, 1899	103,	107	105½	103½
Eastern Extension	11½,	11¾	11 7-16	11½
German Union	9½,	10½	—	—
Globe Telegraph and Trust Company	7¼,	7½	7⅝	7 7-16
Do. Preference	12½,	13	13	12½
Great Northern	12⅝,	12⅞	12⅞	—
Indo-European	31½,	32½	—	—
Mediterranean Extension	1¼,	1⅜	1⅜	—
Do. Preference	2,	4	—	—
Reuter's	9½,	10	—	—
Submarine	240,	250	—	—
West India and Panama	15-16,	1 1-16	1	1 15 16
Do. 1st Preference	6½,	6¾	6⅝	6½
Western Brazilian	6,	6½	—	—
West. Union 7 per Cent. 1st Mortgage	122,	124	—	—
Do. 6 per Cent. Sterling Bonds	103,	106	—	—

TELEPHONES.

Consol. Telephone and Maintenance	7-16,	9-16	9-16	7-16
Oriental	5-16,	7-16	⅜	—
United Telephone	8½,	8¾	8½	7-16

ELECTRIC LIGHT.

Anglo-American Brush Lgt. (£7 paid).	3½,	3¾	3¾	3½
Do. (fully paid)	6¾,	7¼	—	—
Hammond Light	1¼,	1½	1½	1⅜
Swan	1 15-16,	2 1-16	2⅛	2
Maxim-Weston	1-16	3-16	—	—

MISCELLANEOUS.

Telegraph Construction	33½,	33¾	34	33½
India Rubber, Gutta Percha, and Telegraph Works	29,	30	30	29½

THE ELECTRIC LIGHT SUPPLIED MORE CHEAPLY THAN GAS.

The HOLMES-EMMENS BATTERY SYSTEM has been successfully adopted for many important installations, and is simple, cheap, and efficient; and by utilising the chemical products of the Batteries it enables the Electric Current to be profitably supplied at low rates. The ECONOMIC ELECTRIC COMPANY (Limited) are now prepared to CONTRACT for the LIGHTING of Country Mansions, Industrial Establishments, Towns and Villages by this system, charging moderate prices for the plant required, and undertaking the efficient maintenance of the installation for a rental equal to the cost of the same amount of light with gas at 5s. per 1,000 cubic feet in country districts and 3s. 6d. in or near large towns.

Apply to the Managing Director, Dr. Stephen H. Emmens, 9, Soho-square, London, W.

Applications for Local Agencies are invited from persons who are in a position to establish district stations for working the surrounding neighbourhood.

WORKS MANAGER WANTED for large ELECTRICAL FACTORY. Must be thoroughly competent to estimate fo piece work, and to superintend the making of electrical and telegraph instruments and of dynamos and fittings for electric lighting. Apply by letter, stating qualifications and salary required, to OMEGA, THE ELECTRICIAN Office, 396, Strand, W.C.

SITUATION WANTED as JUNIOR ELECTRICIAN or ASSISTANT. Good practical knowledge of electric lighting machinery—E. W. T., 14, Oxford-place, Bexley, Kent.

TURKISH PATENTS.

NOTICE TO PATENT AGENTS AND INVENTORS.

The undersigned having established a special agency in Constantinople, are prepared to SECURE PATENTS in TURKEY for all inventions not yet in use in that country for £35, including drawings of average amount.

Special terms to Patent Agents.

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6, LORD-STREET, LIVERPOOL
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INSULATED ELECTRICAL WIRE, Silk, Cotton, or India-rubber covered. Conductivity guaranteed. German Silver Wires for Resistance. Braided Handle Cord, Silk Cord for Electric Bells, &c.—WILLIAM RICKARD, Derby London Agent (stock kept), EDWIN HOLLOWAY, 2, Gutter-lane, E.C.

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NOTES.

83. "MALABAR."—This troopship has been lighted throughout by the Edison Company.

THE ST. GEORGE TELEPHONE COMPANY.—This Company have removed from 18, Telegraph-street, E.C., to temporary offices at 35, Coleman-street, E.C.

MADRID.—On the occasion of the military review at Madrid on Monday last the whole length of the Prado was illuminated by electric light in the evening.

THE PATENTS FOR INVENTIONS BILL.—This Bill was read a second time in the House of Lords on Thursday, 9th inst., and considered in Committee last Thursday.

THE NEW LAW COURTS.—It is understood that a telegraph office will shortly be opened in the new Law Courts. It will be situate near the entrance to the central hall.

TARIFFS TO VALPARAISO AND CHILI.—The rates to Valparaiso and other places in Chili have been reduced to 12s. 8d. per word by all routes as from the 15th inst.

ELECTRIC LIGHTING IN COLLIERIES.—The surface works of the Bascoup Colliery, in Belgium, are lighted by Edison lamps, the current being supplied by Gramme machines.

UTILISING THE MOTION OF THE WAVES.—It is reported that the New South Wales Institute of Surveyors have been discussing a proposal placed before them for utilising the waves of the ocean to produce power for the purpose of electric lighting.

WEDDING IN THE ELECTRICAL WORLD.—On the 9th instant, at Marylebone Church, the marriage was solemnised of Mr. Henry Crookes, son of Professor Crookes, F.R.S., to Nina, youngest daughter of Mr. C. E. Spagnoletti, telegraph engineer to the Great Western Railway.

AN EARTHQUAKE IN BOSNIA.—A Reuter's telegram states that a violent shock of earthquake, lasting five seconds, and accompanied by a subterranean rumbling, occurred at Serajevo, in Bosnia, at half-past four on the morning of Tuesday last. Its direction was from west to east.

CINCINNATI INDUSTRIAL EXPOSITION.—This exposition, as our American friends call it, will open on the 5th of next month, and continue open until the 6th October. Electrical apparatus will form a prominent feature of the exposition, and numerous medals and awards will be given in this section.

THE BUSHMILLS ELECTRIC RAILWAY.—The Lord-Lieutenant of Ireland has signified his intention of visiting county Antrim, Ireland, on the 14th of next month, for the purpose of inaugurating the Electric Railway connecting Bushmills and the Giant's Causeway, which has been constructed by Messrs. Siemens Bros.

A SECONDARY BATTERY DECISION.—"The patent interference case of N. S. Keith, of the American Electric Storage Company of New York, against Charles F. Brush, of the Brush Electric Company of Cleveland, Ohio, was decided at Washington, on the 2nd inst., priority of invention being awarded to Brush."—*Electrical World.*

SPAIN.—The Direct Spanish Telegraph Company's cable between Falmouth and Bilbao is interrupted. The company notifies that arrangements have been made by which telegrams for Bilbao, Madrid, and other places in Spain, can, during the present interruption of their Bilbao cable, be promptly forwarded by the Eastern Telegraph Company's route.

ELECTRIC LIGHTING IN THE CITY.—We understand that the Brush Company, the only survivors in the City, have expressed their willingness to undertake the lighting of the district in the City, comprising Queen Victoria-street, Queen-street, Queen-street-place, and Southwark Bridge, vacated by the Maxim-Weston Electric Light Company.

THUNDERSTORM.—Telegrams from Geneva, dated the 15th inst., speak of a very violent thunderstorm as having occurred in the Jura on the morning of that date. Several houses are reported to have been struck, and villages set on fire, whilst the telegraphic and telephonic service was deranged. The centre of the storm seems to have been about Neuchâtel, where for some twenty minutes the sky is reported to have been in a continual blaze.

ROYALTY AND THE TELEPHONE.—A telephone from Ballater to Balmoral is being erected by Messrs. Tasker, Sons, and Company, of Sheffield. The poles are placed along the north side of the turnpike road, and cross the Dee near the suspension bridge at Crathie to Dr. Profeit's and on to the Castle. A wire is carried from thence to Abergeldie, crossing the Dee near the cradle. The telephone will be ready for use by the arrival of Her Majesty, which is arranged for the 25th inst.

NEW PRIMARY BATTERIES.—MM. Lalonde and Chaperon use cupric oxide, caustic potash, and zinc, obtaining an E.M.F. near to one volt, with an internal resistance of $\frac{1}{3}$ to $\frac{1}{4}$ of an ohm. The small cells give two amperes current, the large cells give from 15 to 30 amperes. This battery has been successfully tried in telephonic work.—Mr. G. Dumont, writing to *La Nature*, describes a new sulphate of copper battery, a modification of the Callaud battery, in which a tube of lead is plunged into the liquid instead of the copper plate.

ANOTHER SHOCK OF EARTHQUAKE IN ISCHIA.—On Saturday night last the population of Serara Fontana was alarmed by premonitory symptoms of an earthquake. Large fissures had formed, emitting dense vapours on the south side of Epomeo. The old smoke vents ceased to be active, and hot springs discontinued flowing, while rumblings succeeded each other frequently. The Minister of Public Works left at 5 a.m. by steamer for the spot, and on a tour of inspection round the island. At 6:45 a.m. Casamicciola experienced a strong shock, preceded by loud subterranean noises. Several damaged houses fell in, fortunately without loss of life.

THE EDISON SYSTEM IN NEW ZEALAND.—The *New Zealand Times* of the 25th May last contains a long account of the introduction of the Edison system into the Government printing office, Wellington. The total number of lamps used is 65, of the A type (16 candle-power), the current being supplied by an Edison dynamo, driven by one of Marshall and Co.'s 10 horse-power portable steam engines. The work has been carried out by Mr. E. J. Hayes, under the superintendence of Mr. Willis J. Snow, the representative of the company in New Zealand. The *Times* speaks very favourably of the new light as opposed to the gas formerly used.

DEATH OF AN ELECTRICIAN.—The death is announced as having taken place at Brockton, Massachussetts, U.S., during the last week in July, of Mr. W. T. Carlton, an Englishman by birth, and one who was intimately connected with the telegraph in its earlier days. He held a high appointment on the Euphrates line of telegraph in 1866, and was resident at Teheran during the terrible famine of 1870. Later on he joined the Bell Telephone Company in London, was afterwards employed by Messrs. Siemens Brothers in cable testing, and finally went to the United States, where he was connected with telephonic enterprise until the day of his death.

A REVISED INDEX OF PATENTS.—In the House of Commons on Monday last, Sir E. Wilmot asked the President

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of the Board of Trade whether the revised index of patents promised some time ago to the Associated Chambers of Commerce had been completed; and, if so, when it would be published.—Mr. Chamberlain said he was not aware that any promise had been made on the subject; but he was informed that a revised index between 1817 and 1852 was nearly completed, and that the very important index from 1852 to the present time would be proceeded with almost immediately. He had, in view of the passing of the Patents Bill, asked for a report of such matters as might be required if the Bill passed into law.

Electric Head Light.—A commission appointed in Bavaria to test the electric lighting apparatus for locomotives invented by H. Sedlaczek, of Vienna, has reported that, on a cloudy night, the light made it possible to distinguish objects on or near the track, including the colour as well as the form of signals, at a distance of 800 feet in front of the locomotive, at which distance small newspaper print could be read by the light of the lamp. In passing stations the position of switches could be seen distinctly, and the light was visible for a distance of 2½ miles. The light, it reports, burns very steadily, and was not disturbed by the motion of the engine. It is so arranged that on curves it turns automatically, so as to throw light on the track.

The British Association at Southport.—The *Southport News* says:—"We are informed that Sir Wm. Siemens has consented to give an exhibition of electric lighting in Southport on the occasion of the visit of the British Association next month which will exceed anything previously produced in the provinces. The exhibition will be held in the Winter Gardens, and will consist of 26 arc lights and 140 incandescent lights. Each of these arc lights will have five times the power of the existing lamps in the gardens. It is estimated that the expenses attending the fixing and working of the light will entail over £200, towards which the Local Executive Committee contribute £100, Sir William generously undertaking to pay out of his own pocket the extra cost, whatever it may amount to."

The Vienna Electrical Exhibition.—We understand that at the urgent request of the British Commissioners the Council of the Society of Telegraph Engineers and of Electricians have arranged to collect further exhibits of electrical apparatus for the British section, and have already obtained promises of instruments and other objects of interest from Messrs. Siemens, Mr. Latimer Clark, Mr. Robert Sabine Professor Hughes, Mr. Stroh, and others. We wish the council every success in their endeavours to render the British section more worthy of the country than it promised to be, but their task will be no easy one at this late period. The exhibition opened yesterday, although the exhibits are as yet in rather a backward state. All the British Commissioners are now at Vienna, with the exception of Sir Wm. Thomson.

Strike of Telegraphists in America.—The New York correspondent of the *Daily News* telegraphed on Sunday last as follows:—"The telegraph strike continues practically unchanged. A small number of strikers return to work daily, but the main body stands firmly against submission. The general opinion pronounces the case of the strikers hopeless. The company complains that many wires are cut every night, and charges the act to those on strike." A telegram from Philadelphia, dated 15th Aug., says:—A committee of six of the telegraphists on strike called this morning on General Eckert, and asked on what terms the strikers would be taken back into the Western Union Company's service. General Eckert recommended the strikers to apply to the superintendents for the terms upon which a resumption of work would be permitted.

Electric Lighting in Melbourne.—According to the *Melbourne Argus* the Legislative Assembly Chamber has been successfully lighted by the Australasian Electric Light, Power, and Storage Company, by means of 70 Lane-Fox incandescent lamps of 20 candle-power each, supplied by one of the Brush Company's new 100-light incandescent machines. The Chamber had previously been lighted by gas, and those present were unanimously of opinion that the electric light compared most favourably with it. The electric lamps revealed the beauty of the Chamber more effectually than gas had done, and gave a better light everywhere. The effect on the atmosphere was most marked, a point of very great importance to all places of this kind, especially in warm climates. We understand that a considerable extension of the lighting is contemplated.

Competition in America.—Considerable interest, says the *Pall Mall Gazette*, will be excited in telegraphic and financial circles by the report that Mr. Mackay, the well-known Californian millionaire, is backing the projected Postal Telegraph Company, which has been started to compete with the Western Union. The total capital of the new company is fixed at about five millions sterling, of which Mr. Mackay has taken £200,000. The contest between Mackay, the millionaire of the Pacific, and Jay Gould, the millionaire of the Atlantic coast, who is behind the Western Union, will be watched with much interest. Unfortunately, although these monetary potentates may for a time engage in a warfare from which the public reaps advantages, their feuds usually end in a close alliance, for the purpose of recouping themselves for their losses at the expense of the community.

Execution by Means of Electricity.—Sir W. Harcourt was subjected to some considerable amount of questioning in the House of Commons, the other night, as to the recent unfortunate circumstances attending the execution of a man named James Burton at Durham last week, the facts of which were reported in the daily papers. Mr. Cowen asked the Home Secretary whether "some more scientific mode of killing criminals by electricity or poisoning could not be adopted," in place of the ordinary procedure as entrusted to the hands of Marwood at the present time. This matter has been the subject of some considerable discussion and thought at different times, and we believe that numerous devices for despatching criminals rapidly and painlessly have been invented, but up to the present they do not seem to have emerged from the laboratory stage. In all probability capital punishment will be abolished before electricity is summoned to the aid of the executioner.

Electric Lighting in American Mines.—According to an Arizona paper a number of mining companies in Arizona territory are about to adopt the electric light to facilitate operations under ground, as well as on the surface, notably the Silver King Mining Company, the Howell Smelting and Mining Company, and the Conger Mill and Mining Company. At the Silver King mine it is proposed to use four Brush lights above ground and two below, together with twenty-five Swan incandescent lamps. A dynamo located near the main shaft will supply the current to the arc lights and storage batteries in the lower levels of the mine. The batteries will supply the current to the incandescent lamps. Fixed lamps are to be suspended from the roofs of galleries, and the portable lights are to be attached to flexible conductors for convenience of shifting. These lights are to burn continuously, night and day. In the reduction works of this

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company both large and small lights are also to be used, a separate dynamo and two storage batteries supplying the current. The arc light circuit in the Silver King Mine will be about half a mile in length.

THE WIRE QUESTION AGAIN.—From vestries, local boards, and private individuals, the agitation on the subject of underground as against overhead wires, has at length spread to the House of Lords. On Monday last Viscount Sidmouth asked Her Majesty's Government whether, in the extension of the telegraph system which was now contemplated, they intended to consider the feasibility of carrying the wires underground, as was done in some other countries, instead of upon poles according to the present universal practice of Great Britain, to the detriment of the landscape. It had been stated that the expense of carrying wires underground was considerably more than carrying them overground, and that it was as much as 100 to 30, but he had lately received information from America to the effect that, in consequence of recent inventions, the expense, so far from being greater, was less than the overhead method.—The Duke of Buccleuch, speaking from a purely practical point of view, pointed out the great risk incurred by travellers in consequence of the breakage of poles after snowstorms, a risk which would be wholly removed by a system of underground wires.—Lord Thurlow assented to the desirability of carrying wires underground, but said the great obstacle was the additional expense. He would, however, take care that the remarks of the noble lord were brought before the Postmaster-General, who would consider them with attention.

THE LORDS AND THE ELECTRIC LIGHTING ORDERS.—Why the Lords had a special committee to report upon some of the electric lighting orders, and to receive the same evidence that had been given a week or so before to the Committee of the House of Commons is beyond our comprehension. The Committee of the House of Lords, however, agreed to pass the orders, and hence, we suppose, the remainder of the path of the present Bills will be without hindrance. We have never been very ardent supporters of the existing state of things, but we are decidedly of opinion that the throwing out of the orders, which have been specially opposed, would have delayed real work. We are not sure, but we should not be surprised, if the orders obtained without much trouble do not prove to be somewhat of the nature of white elephants—if retained in the hands of their promoters—though we are inclined to think with one of the witnesses that an order obtained will be valued as so much property and sold to the best purchaser. We are quite sure, however, that some of the orders obtained with light hearts will prove heavy burdens, simply because those who manage the affairs are utterly incompetent to understand the requirements of the case. They seem to imagine that any and every light will be eagerly welcomed, and they fail to see that nine-tenths of the present apparatus is utterly useless when required for general lighting purposes. Much of the lighting established hitherto has been carried out at a loss, or even gratuitously as an advertisement, but this cannot be done when work in real earnest commences, nor will shareholders be content to wait for ever for some signs of a return.

DYNAMITE STRUCK BY LIGHTING.—The following well-authenticated case of the firing of a dynamite magazine is of interest :—About a month ago, says the *Engineering and Mining Journal* of New York, the company operating the salt mines at Avery's, or Petit Anse, Iberia Parish, La., received a large quantity of dynamite for blasting purposes. The same was stored in a magazine situated about four hundred yards from the works. Large trees were in close proximity. On Saturday, July 21st, a few minutes past twelve o'clock, a terrific storm burst on the island. Torrents of rain fell, and peal after peal of lightning rent the skies. The workmen had barely left and reached the boarding-house, situated at some distance from the works, when the lightning struck the magazine, and immediately there followed an awful explosion. For a few minutes, all seemed entirely paralysed. Recovering, some rushed out to ascertain the cause. It was then discovered that the whole building in which was stored the explosive compound had disappeared, and in its place was left a yawning chasm fifteen or twenty feet deep by about one hundred feet in length. The trees surrounding were prostrated and shattered. One, $2\frac{1}{2}$ feet in diameter, was carried by the immense power in the blast two hundred yards from where it previously stood. Every building on the island contiguous to the mines was shaken in a terrible manner, causing every glass door and window to part with its glass. The buildings containing the mills and machinery were much damaged, preventing access to the shaft for the time being. Eight box-cars, ready to be loaded, were entirely crushed in their upper part, the running gear remaining intact.

TELEPHONE WIRES AND THE PUBLIC.—On Saturday, in the City of London Court, before Mr. Commissioner Kerr, an application was made by Mr. G. Kebbell, solicitor, Seething-lane, on behalf of Mr. German, the freeholder of land at Bow, for an order by way of injunction restraining the United Telephone Company and directing them to remove certain posts which they had erected on his property, as well as the wires suspended therefrom. The proceedings, as given in the daily press, were somewhat amusing, as will be seen from the following report :—Mr. Scott, barrister, for the defendant company, contended that they had obtained leave from the lessees of certain parts of the land to erect the posts. Mr. Kebbell denied this, and said that the posts were really placed on the plaintiff's land, over which the lessees had a right of way, and that the wires were beyond doubt suspended across the land in question, which was unoccupied. Mr. Scott: Your Honour knows that it has become a custom for telephone companies to place their wires from house to house, and few people object, as it is a matter of public convenience. His Honour: That cannot give the companies a right to put their wires across any man's land. The law is that an owner is entitled to the enjoyment of everything between his land and the heavens. Why does not the plaintiff cut the wires? Mr. Kebbell: That is just the difficulty. We are afraid that if we did so the wires would fall on other people's land and endanger life. His Honour: But you would not be liable to a charge of manslaughter. Mr. Kebbell: Without discussing my client's legal position, I could not allow him to take a course by which life might be imperilled. His Honour: No doubt. The matter had better stand over till the hearing, and I promise that you shall not be prejudiced by the delay. The case was accordingly adjourned.

THE ÆSTHETICS OF ILLUMINATION.—We had thought that everybody was charmed and satisfied with the illumination at the Fisheries Exhibition, but we were mistaken. A conspicuous feature of the recent series of evening *fêtes* at the Fisheries Exhibition, says the *St. James's Gazette*, has been the failure of the illuminations; and it may be worth while, perhaps, now that the management has had plenty of (well-deserved) congratulation, to administer a little criticism. Nothing is easier, given the funds, than to produce that "blaze of light" which reminds the average reporter of " the

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Arabian Nights" (and which he calls "a fairy scene"), and nothing is more certain than that a crowd, suddenly dazzled, when emerging upon the spectacle will, in the first impulse of surprise, exclaim "How beautiful!" But this is not illumination in any complimentary sense of the word. Those who have been in the East and seen what wonderful effects can be attained with the poor materials that Orientals can command, detect at once that the fundamental laws of display have been violated. In the first place, our colours are too violent; in the next, the lighting is all too low on the ground; and, finally, every opportunity of sky-line effects is punctually wasted. Illumination, to be really beautiful, should be in the air and not on the ground; to be artistic, it should reveal the landscape, and not conceal it; yet at South Kensington, where the site lends itself admirably to the purpose if properly appreciated, the management squander thousands of lights that glare on the eyes and offend the nose from footpaths and grass and neglect the lines of the surrounding architecture. The same lamps that bewilder the visitors and dazzle them would be exquisite if placed aloft; and a dozen twinkling sparks upon a cornice produce an effect equal to an acre of obvious oil upon a flat ground, for the surrounding buildings would then be thrown up in aerial relief against the night instead of, as now, being thrown back into ugly gloom.

Electric Lighting at the Welsh Eisteddfod.—Messrs. Williams and Sons, of Cardiff, have fitted up a number of Weston arc lights in the buildings in which the National Eisteddfod has been held at Cardiff. The lamps and dynamos, &c., were supplied by the Maxim-Weston Electric Company. The main building, which is the new engine shed of the Taff Vale Railway Company, was lighted by 14 Weston arc lamps, arranged in three separate circuits. The current was supplied by two Weston dynamos, one driven from a fixed engine and one from a portable engine. The three circuits each extended in different directions outside the building to the entrances of the grounds and to the Taff Vale Railway Station. In all 33 lamps of 1,500 candle-power each, were used. By this arrangement the chances of a failure of light in the building were rendered almost impossible. In addition to the above, the fine art galleries were lighted by 70 Maxim lamps of 50 candle-power, arranged in rings suspended from the ceiling about 6ft. from the walls of the rooms. No one who entered these rooms could fail to be struck with the beauty of the light, which leaves nothing to be desired for showing pictures and other works of art to their best advantage. The system of lighting is similar to that adopted in the Glasgow art galleries, which have been lighted for several winters by Maxim lamps. During the holding of the Eisteddfod Cardiff Castle, the residence of the Marquis of Bute, was partially lighted by means of Swan lamps, 220 in number, the same, in fact, as were fited up by the Swan United Company in January last under the superintendence of Mr. Massey. On this occasion the power was supplied by the officials of the castle, whilst the installation was worked by Mr. A. H. Walker and Mr. Hamilton Baker, two assistants of Mr. Massey, of Twyford. The lights gave great satisfaction. Cardiff itself was gay with electric lights. The Great Western Electric Light Company had about thirty Brush lamps running in various places; the proprietors of the *Western Mail*, five large Crompton lamps; whilst a few small arc lamps were dispersed about, the current for these being supplied by Lumley dynamos.

Grand Theatre, Islington.—This is the second metropolitan theatre at which the electric light has been successfully adopted as a permanency. The installation, which has been supplied by the Hammond Electric Light Company, consists of 85 20 candle-power Swan lamps in the auditorium, and eight 50 candle-power lamps outside the theatre. These are worked by a Ferranti 100-light dynamo with a D6 Siemens exciter, the motive power being an eight horse-power (nominal) Otto gas engine. The lamps are very tastefully arranged in front of the balconies in groups of three, a circle of single lamps surrounding the central chandelier, while single lamps and pairs are placed in diamond shaped recesses at regular distances from the centre; all these are encased in yellow ground glass globes which diffuse the light and produce an exceedingly soft and agreeable effect. The circuit is a single parallel and is controlled, for the purpose of raising or lowering the light during the intervals of the play, from a switch at the side of the stage. By means of this switch three intermediate grades between complete darkness and brilliant light can be obtained. Each portion of the circuit, such as the several balconies, and the ceiling, is provided with a safety cut out. The lamps in the balconies are very ingeniously arranged in sets of three in small recesses covered with oval shades of yellow ground glass; these recesses can be opened from behind, and the support of the lamps working on a hinge the latter can readily be got at in case of need. The management originally intended to light the theatre throughout by electricity, but it was found there was not sufficient space on the basement for a larger engine than the one now in use, which taxes the limits of the engine-room to the utmost; it is proposed, however, to light the lobbies and saloons by means of accumulators to be charged during the day by the plant now at work. So great reliance was placed on the electric light that on the night the theatre opened the large gas chandelier in the ceiling was not lighted, and had any failure occurred on the part of the electric light the theatre would have been in almost total darkness. When the current was turned on on this occasion a hearty reception was accorded to the light by the audience assembled. The installation is under the charge of Mr. South, Messrs. Hammond and Co.'s electrician, to whom we are indebted for much of the above information.

Diploma of Electrical Engineer at Liege University.—The following information, in addition to that published in a note in our last week's issue, may be of interest:—"A Belgian Ministerial decree, dated 24th July, 1883, institutes a diploma of Electrical Engineer at the Liege University to be conferred:—(1) on honorary and civil mining engineers of the Belgian section, who shall, after an additional year of special study, satisfy the conditions A of the programme; and (2) on mining or mechanical engineering pupils, who, after two years of special study, shall satisfy the B and C conditions of the programme. Certificates may also be granted to the *ingénieurs des arts et manufactures* and the mechanical engineers of the foreign section, who shall have successfully followed the course of the special year, conformably with programme (A), to the exclusion of the mathematical theory of electricity. A hundred points are allotted to each of the three programmes, A, B, and C. Programme A of the supplementary year's studies for electrical engineers consists of:— (1) The theory of electricity, 20 points; (2) electro-technics, including the various applications of electricity, 35; (3) work in the electrical laboratory, 25; and (4) the devising projects connected with the various branches of electro-technics, 20 points. The medium of points is required on each of the subjects; and, in the examination for certificates, No. 1

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counts for 15, and No. 2 for 40 points. Programme B for the first year of special study consists of:—(1) The theory of electricity, 14 points; (2) electro-technics (1st part), 14 points; (3) applied mechanics, 20; (4) industrial physics (thermody-nomics and applications), 14; (5) industrial architectures (1st part), 10; (6) machinery and machine drawing, 10; (7) work in the electrical laboratory, 10; and (8) the English or German language, 8 points. A mean of points is required on Nos. 1 and 2 together, 3 and 4 together, 5 and 6 together, and on No. 7, and on the whole of the subjects. Programme C for the second year of special study consists of:—(1) Electro-technics (2nd and 3rd parts), 25 points; (2) metallurgy (1st and 2nd parts), 15 points; (3) the working of railways, 10; (4) industrial architecture (2nd part) 12; (5) drawing, including architectural projection, 10; (6) work in the electrical laboratory, 10; (7) the designing of projects, involving the applications of electricity, 10; and (8) the English or German language, 8 points. The medium of points is required on the whole of the subjects together on No. 1, on Nos. 2 and 3 together, on Nos. 4 and 5 together, and on Nos. 6 and 7 together.

The Telephone Case in America.—The Examiner of Interferences at the United States Patent Office, Mr. J. B. Church, has lately rendered a decision in the long contested telephone case, in which the parties interested were Bell, Gray, Edison, M'Donough, Dolbear, Boelker, Blake, Irwin, and Richmond. The *Scientific American* understands that this decision disposes of some eleven cases in all, in which the above parties were represented. These cases have been pending before the Patent Office since 1878, and were argued before the Examiner about a year and half ago. It has been necessary for the Examiner to go over a vast amount of testimony, and it is understood that he has performed the duty with the greatest care; his decision is stated to cover nearly seven hundred pages of manuscript. Priority of invention is awarded to Bell for the art by which oral conversation or sounds of any description can be telegraphically transmitted; also for the improvement in the art of transmitting vocal sounds or spoken words telegraphically; also for the acoustic telegraph, including sound producers as well as reproducers on armature plate, the electro-magnet for the same, and a closed circuit passing from the helix of such electro-magnet to the source of undulatory electric energy; also for the telephonic transmitters and the combination in one circuit of two or more discs or diaphragms; also for the combination for rendering audible acoustic vibrations; also for the combination in an acoustic telegraph of an electro-magnet and a polarised armature, and the combination in an acoustic telegraph of an armature plate polarised by induction, a resonant tube, and an electro-magnet and circuit connections. Priority of invention is awarded to Edison, although he did not claim it, for the transmitter, consisting of the combination in an electric circuit of a diaphragm and a liquid or equivalent substance of high resistance, whereby the vibrations of the diaphragm cause variations in the resistance of the electric current; also for the combination in a telegraph instrument operated by sound of two or more electrodes placed in an electrolytic liquid, and operating to increase and decrease the resistance of the electric circuit by the movement derived from the diaphragm; also for a spring forming or carrying one electrode, and constantly pressing against the other electrode and the diaphragm to maintain the required initial pressure between the electrodes and yield to the movements of the diaphragm. Priority of invention for "a telephone receiver, consisting of the combination in an electric circuit of a magnet and a diaphragm supported and arranged in close proximity thereto, whereby sounds thrown upon the line may be reproduced accurately as to pitch and quality," is awarded to McDonough.

Electric Lighting in New Zealand.—The electric light, which has proved so useful in many of our harbours at home, is now finding its way to our colonial ports. Amongst others, Lyttelton, New Zealand, has made trial of it. A description of the inauguration of the Brush light at Lyttelton Harbour has just reached us. From this it appears that the New Zealand Electric Light and Power Company, early in this year, entered into a contract with the Lyttelton Harbour Board for fitting up a 16-light Brush plant for the sum of £1,000, subject to a two months' trial of the efficiency of the system. The installation was completed about the 1st of May last. We take the following details from the *Lyttelton Times* of the 21st of May last:—"It consists of 16 Brush arc lights, each of 2,000 candle-power, erected on the works surrounding the inner area of the harbour. Three of these are at the graving dock, two on the steamers' wharf, four on the Gladstone pier, and the remainder distributed singly on the various other wharves. Each lamp is fixed upon a kauri post about 30 feet in height, and is protected by a kind of hood, the interior of which serves the purpose of a reflector. The 'cable' connecting the lamps with the dynamo is laid underground in wooden piping from the dock to Peacock's wharf, a distance of about 1,000 yards. Thence it is conducted to and along the Gladstone pier in a wooden casing, protected by iron capping, fixed beneath the planking of the wharves. The cable passes to the lamps along grooves cut in the posts, and covered with boards nailed on the posts. The circuit is completed by a submarine cable laid across the basin from the Gladstone pier to the dock. Earth plates have been provided in order to continue the working of the system should this cable be injured. The dynamo machine, which is of the newest English pattern, is lodged in a compact little building constructed of iron, and match lined, adjoining the end of the dock engine house. The machine is capable of working up to 800 revolutions per minute. In the building just alluded to is the steam engine used for driving the dynamo. It is a high pressure condensing engine of 16 horse-power nominal, running at a speed of 110 revolutions per minute, and was made by Messrs. Scott Bros., of Christchurch. Steam is supplied to the engine from one of the boilers of the dock pumping machinery. It was at first intended to use one of the dock engines for the dynamo, but as such an arrangement must, under any circumstances, have been of a temporary character only, it was finally decided to erect a special engine for the purpose. In conclusion, it may be mentioned that the whole of the work in connection with fitting up the installation has been done by Mr. Prince, engineer to the company, ably assisted by that enthusiast in electrical matters, Mr. Meddings, and the officials of the Harbour Board." As a matter of course, the inauguration of the lights, which took place on Saturday night, the 19th May, was made the occasion of considerable feasting and toast drinking, the Lytteltonians evincing great interest in the new system of lighting. According to the report of our contemporary above mentioned, the new light was a decided improvement on the old gaslights. It may be mentioned here that the first negotiations for the introduction of the electric light into Lyttelton were carried on by Sir Julius Vogel, as the representative of the Australian Brush Company, but were subsequently completed by the New Zealand Company, who acquired the Brush patents from the Australian Company.

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POTENTIAL, CURRENT, AND RESISTANCE.—III.

BY JOHN T. SPRAGUE.

(CONTINUED FROM PAGE 282.)

27. *Contact and Chemical Theories.*—From the first days of the discovery of current electricity two theories have been maintained to account for the origin of the "electromotive force." One school contends that the current is due to a *force* set up by the *contact* of heterogeneous bodies, by which a disturbance is effected in the supposed normal distribution of electricity, assumed to be a constituent of all bodies; another school attributes the origin of the current to the action of *chemical affinity*.

28. The *contact theory* has undergone various changes. At first it was held that the force originated at the point of contact of the *two metals* of the battery, say, copper and zinc. Faraday demonstrated the production of voltaic electricity when no metals were in contact, and by a number of proofs absolutely demolished the contact theory in this form, and established the chemical theory by proving, on the other hand, that no electricity was produced except as an accompaniment of chemical action. Then the contact theory was modified so as to include the contact of all heterogeneous substances.

After some time the idea was added that *contact* is the source of the electric *force*, but that *chemical action* was necessary to supply *energy* to maintain the current. Brought into this compass, the matter seems to be reduced to little more than a squabble about words.

29. The *molecular* theory of electricity does, in fact, set aside both these theories by showing how far both are true, for it shows that electric polarisation must needs occur whenever two heterogeneous substances come into contact under the proper conditions.

This "contact," however, is no new mysterious "force" or "difference of potential;" it is the ordinary chemical force of affinity (be that what it may) exerting itself upon *all* its surroundings, whether *within* the molecule constituted by virtue of its action, or *upon the external molecules* brought within its range by this act of contact, which merely means a close neighbourhood, allowing force to distribute itself upon the universal law of the inverse square of distance.

Therefore, this theory is really the chemical theory developed, and sets aside the contact theory, and although this may seem to be a mere verbal distinction, there are principles of deep importance underlying it. The point is whether we have the right to invent some new "force" whenever we want to explain something, or—perhaps more truly—to adopt some sounding word to wrap our ignorance in, and then offer that word as an explanation of the facts we do not understand.

30. There is also a wide distinction between the two theories; the contact theory is essentially *atomic*, and the chemical theory *molecular*. I hinted at this some time ago, and it may sound mysterious at first, and be unmeaning to many, but it involves two widely diverging lines of thought. It will be unmeaning to the purely mathematical mind, which deals with artificial creations and abstractions, and whose natural property the contact theory is. It requires the physical training of chemistry to appreciate; but I will explain my meaning.

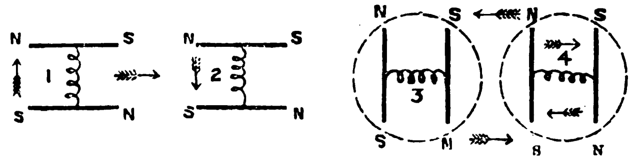
31. There is a theory of electrolysis which we may call "the dance of the atoms." It is supposed (on this theory) that molecules have not the absolutely defined construction involved in chemical formulæ; that a coppering solution, for instance, does not consist of fixed molecules $H_2 O$, $H_2 SO_4$, and $Cu So_4$, but that these molecules are merely temporary formations, and their constituent atoms are perpetually interchanging among themselves, like the ladies and gentlemen in the figure known as the "grand chain;" or, better still, like the gnats one may see on a summer evening flashing here and there and circling for a moment around each other. This strange idea was invented in order to explain why *ions* pass to the two electrodes. These are imagined to exert a force of attraction, each for its oppositely-electrified ion, which during its free moments in this "dance" is gradually drawn over.

32. There is *not a particle of evidence* to support this theory; it is a mere figment of the imagination, and is wholly opposed to the known laws and facts of chemistry, and especially inconsistent with the known facts of thermochemistry; but it just suits the mathematician as distinguished from the physicist, because he seeks to isolate every idea and fraction of an idea and property and ticket it with a symbol, which he then deals with as a kind of individuality or "person."

But the chemical mind, trained perhaps too much the other way, and dealing with concrete bodies, treats the combination of the atoms in a molecule as a rigid, definite union. To the chemist this molecular unity is a true marriage, rather than the promiscuous intercourse of this other theory. He is shocked at the idea of any dissolution of the bonds of chemical affinity, except in the form of a higher affinity, a stronger force which, like death, breaks the original union only because it removes the two parties to it to new and distinct spheres.

Thus it is that the contact theory is related to the *atomic* forces, while the chemical theory is related to the *molecular* forces.

33. The *molecular theory* may be defined thus:—The atoms of matter are endowed (how matters not) with differential attractions, and, apparently, with polar properties, which we may conceive by the figure of infinitesimal magnets, all having N and S ends, but having different magnetic capacities. These atoms unite together in pairs, which partially satisfy each other's polar requirements in a manner which the figure may explain.



Spiral springs holding the lines together with various forces.

1 and 2 represent molecules, held together by forces of polar attraction, represented by spiral springs. They, in fact, resemble pairs of "astatic needles." When they approach to other molecules the closed system acts externally in part, and unites the molecules together, though with a force more feeble than the internal affinity. 3 and 4 convey the same idea more fully. In 3 the internal attraction is shown strong. In 4 it is shown weakened by part of the attractions being diverted externally to the nearest atom of the approaching molecule. This is the action which is correctly described as *electric polarisation*, a weakening of the internal affinities, a tendency to disruption of the molecule by external affinities, and this difference between the internal and external affinities is the E.M.F of any chemical action, or the measure of the so-called "contact potential," the development of which is thus rendered intelligible.

34. These forces are forms of energy, and are measurable directly in terms of energy. The strength of any chemical affinity constituting a molecule is measurable in terms of the *heat of combination*. This is the value corresponding to the spiral springs of the figure. The strength of any chemical affinity tending to break up existing combinations, and to produce new ones, is measured in terms of *the heat set free by the reaction*—that is to say, by the difference of the intrinsic energy *potential* in the first state, and that remaining *potential in the products*. This is easily and usually measureable as heat, and this general recognised fact is embodied in what Berthelot calls the law of *maximum work*.

35. But this is only a phase of a general law of electrical action, which I will formulate thus:—*Wherever there is free energy present* (as heat in a thermopile), or *wherever there is potential energy seeking to become free* (as when chemical affinities can come into play) *in presence of differential molecular structures, or conditions, so arranged that a closed polar chain can be completed, then energy takes the form of electromotive force or electric potential.* The quantity of energy associated with any particular molecular condition, or capable of action upon the definite molecular chain is the measure

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of the degree of electric potential due to the particular condition.

36. It is perfectly well known and admitted that electromotive force is expressed by the potential energy of any chemical affinity connected with it, even by those who maintain the contact theory. It is a certain fact that in electrolysis the act of breaking up a substance into a simpler condition, such as deoxidation, involves the presence of an E.M.F. which takes no part in the production of current, and must be written as $-e$, in order to reduce the E apparently available for that purpose. This $-e$ is just equal to the positive E.M.F. which the corresponding reverse act of oxidation will produce. On the other hand, it is well known that some energy disappears, which is not accounted for in the R of the circuit, and this energy, again, is exactly that corresponding to the chemical union broken up. Here, then, we have the two terms of E and energy connected as equivalent.

37. This is commonly stated in the following manner. The work done in transmitting electricity is as $E \times Q$ (which is simply $E \times C$ in another form, not reckoning time, as $C = Q \div T$), and the same formula applies to doing this against an E.M.F. as in a decomposition cell. In this case a chemical combination is reversed, of which, in most cases, the calorific equivalent—*i.e.*, the potential energy, in the form of heat, has been determined.

Let H represent the heat of combination of 1 gramme of a substance, say, taking Favre's values, hydrogen = 34462 combining with oxygen, and zinc passing to its sulphate = 1623 calories.

Let A be the ampere or coulomb equivalent of the substance, say ·00001022 gramme for hydrogen and 00033324 for zinc, multiplied by 10 to bring it to the C.-G.-S. unit of quantity, the coulomb being 10^{-1} of this.

Let J be the mechanical equivalent of the calory in ergs 42,000,000, 42×10^6 or $4{\cdot}2 \times 10^7$.

Then, the volt being 10^8 absolute units, we have

$$E \times Q = Q \times H A J,$$

and an arithmetical result of this is that $E = H A J$, which means that E, or E.M.F., is equal to energy, which will be made plain by the following examples:—

In the case of hydrogen burning, or in a gas battery we have

H = calories	34462 =	Log.	4·5373405
A = „	·00001022 × 10 =		$\bar{4}$·0095453
J = „	42,000,000 =		7·6232493
	Energy in ergs		8·1701351
Volt = C.-G.-S. units 10^8	=		8·0000000
E.M.F. in volts due to H and O			0·1701351 = 1·480.

This is the experimental value of the reaction as nearly as observation can be expected to agree in the present undefined state of several of the data concerned. Dr. Alder Wright in making the actual comparison found it to be 1·5038.

In the case of zinc forming sulphate we have

H = calories	1623 =	Log.	3·2103185
A = „	·00033324 × 10 =		$\bar{3}$·5227571
J = „ $\frac{4{\cdot}2 \times 10^7 \text{ as before}}{10^8}$ Volt.	=	„	$\bar{1}$·6232493
Volts of E.M.F. due to zinc =		„	0·3563245 = 2·272.

Then 2·272 − 1·480 = ·792 gives us the combined action of zinc dissolving in acid and giving off hydrogen.

38. Hence we have this definition:—*The E.M.F. corresponding to any chemical action is equal to the product of the equivalent weight of the basic ion and of the heat of combination of the two ions* expressed as C.-G.-S. units of work; that is to say, when all the elements are reduced to the absolute system.

It appears difficult to understand how, in the face of such a fact and such an accepted law, any one can dispute the statement that E.M.F. is merely a metamorphosis of chemical affinity, or talk about *contact* potential in face of the evidence that both chemical affinity and E.M.F. are forms of energy, correlative, convertible, and expressible by identical figures.

39. The foregoing calculation and formulæ are useful in order to follow out a line of reasoning, and to put the facts in the form adopted by most writers. But there is a much simpler mode of calculation, and one which has the great advantage of leading us up to a natural law instead of a mere arithmetical expression.

Let H be the heat in calories per *gramme equivalent*, in which form it is commonly stated, or which can be calculated from H A above.

Let J be the calories corresponding to 97808·5 amperes (that being the time in which an ampere current effects 1 gramme equivalent of electrolysis) × by the joulad (in calories) the work of 1 ampere = 23287·7 Log 4·3671271.

Now $H \div J$ is the E.M.F. in volts due to the reaction. Thus we have

H = hydrogen	34462	Log.	4·5373405
J = "equi-volt"			4·3671271
E.M.F. of H + O, as before			0·1702134 = 1·480.

37. The Equi-volt.—I must now explain this term and unit of my own. It is compounded from "equivalent" and "volt," because it expresses *energy in the terms of one volt of E.M.F. under unit conditions of current and resistance, but correlated to the true* natural *unit of electric quantity*, the chemical equivalent of matter to which electricity is connected, and the neglect of which makes the nature of electricity incomprehensible.

The ordinary system of measurement is based upon energy, and the definition of electric quantity is purely artificial. The description of quantity in the form of dimensions as $M^{\frac{1}{2}}, L^{\frac{1}{2}}$, has no meaning except in connection with energy related to it. Yet the best known of all the facts of electricity is that which corresponds to the idea of a physical quantity—viz., the definite chemical relation of a quantity of electricity, or current, to a fixed equivalent of matter. This relation is comprehensible when we realise that a "quantity of electricity" means really a definite molecular action, most perfectly realised by the mind in the form of one of those molecular impulses described § 33.

The equi-volt, therefore, is simply the energy associated with one such impulse under the conditions of unit force, and in a chain of unit resistance. The actual quantity attached to it will be varied just as is the actual quantity connected to a chemical equivalent or atomic weight, which may be milligrammes or tons with equal correctness.

The value given to it in §36 is that belonging to 1 gramme of hydrogen or the equivalent of any substance, which has the advantage of forming a part of the volt and coulomb system. The only objection to it is its magnitude as compared to the ampere current, but even this is no disadvantage in many applications of electricity, and especially in connection with light and metallurgy.

But it is more convenient for some reasons to use a value related to our English system of measures, such as the foot-pound. There is no difficulty about this, as we need only multiply the value in calories (such as are used § 35 and 37) by ·198547 or Log. $\bar{1}$·2977983, when we have the corresponding expression in "foot-pounds per grain equivalent;" which is, in fact, the work corresponding to an ampere current for 6,338 seconds during which one grain of hydrogen is set free (as in a Smee cell). This value is 4,673 foot-pounds, and this form of the equi-volt I shall use.

Fire by Lightning.—The new portion of the University of Indiana, at Bloomington, was set on fire by lightning during a thunderstorm on the night of the 12th of July, the electricity travelling along a telephone wire which served the institution. The laboratory, museum, and library were completely destroyed. The museum contained a collection of fishes, made by Dr. Jordan, which was thought to be the largest and most valuable in the United States. There were 15,000 volumes in the library, besides the so-called Owen collection, the loss of which is believed to be irreparable. The loss is estimated at 200,000 dols., of which only 30,000 dols. is covered by insurance.

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ELECTRICITY AND PHYSIOLOGY.

In these days, when electricity is largely used as a curative agent—when it is suggested that it should be used as a punitive agent—it is is well to keep in view the experimental work that has been accomplished and the results obtained by the employment of electricity in physiological researches. These results are given in a most compendious form in Professor Barker's address on resigning the presidential chair of the American Association for the Advancement of Science. This address was entitled "Some Modern Aspects of the Life Question," and will be found in Part I., Vol. XXIX. of the *Proceedings*. The following extract is taken from the address:—

As a first result of recent work, the living organism has been brought absolutely within the action of the law of the conservation of energy. Whether it be plant or animal, the whole of its energy must come from without itself, being either absorbed directly or stored up in the food. An animal, like a machine, only transforms its energy. Lavoisier's guinea pig placed in the calorimeter gave as accurate a heat-return for the energy it had absorbed in its food as any thermic engine would have done. But the parallel goes further. The mechanical work of an engine is measured by the loss of its heat, and not of its substance. So the mechanical or intellectual work of a living being is measured by the amount of carbon rather than the amount of nitrogen which is excreted. The energy evolved daily by the human body would raise it to a height of about six miles.

But, besides heat, work may be the outcome of the organism, and this through the agency of the muscles. Their absolute obedience to mechanical law in their mode of action has been admirably established by Haughton. The work a muscle does it does in contracting. It is to the mechanism of muscle contraction that we are indebted for another illustration of our subject. When work is done by a muscle in contracting, three changes are observed to take place normally in its tissue. First, there is a loss of its electric tension; second, there is an evolution of heat in it; and third, carbon dioxide appears there, and its reaction, before neutral, becomes acid.

Matteucci was the first to observe and to call attention to the remarkable similarity in structure and in the mechanism of operation between striated muscular fibre and the electric organ of certain fishes. Recently, Marey has repeated and extended his observations. In structure, the electric organ is made up, like the muscle, of columnar masses, each separable transversely into vesicular sections. In a torpedo weighing seventy-three pounds, there were 1,182 of these columns in each of the two organs, with 150 sections, on an average, in each column. In the muscles which bend the forearm there are 798,000 fibrillæ. As to the mechanism, alike in muscle and in electric organ, an electric current stimulates action on opening and on closing the circuit, but not when it is flowing; the same phenomena take place in both with the direct and with the inverse current; both are reflex; stimulation of the electric nerve produces discharge, as that of the motor nerve causes muscular shock; an entire paralysis follows nerve-section; curare paralyses both; and tetanus results in both from rapid currents or from strychnine.

Still more striking analogies are furnished by the investigation of the susurrus, or muscular sound, first noticed in 1809 by Wollaston. This sound is produced by all muscles when in the state of contraction, the pitch of the note being not far from thirty vibrations per second. It is evidently only the intermittent contraction of the muscular fibre. A single excitation produces a muscular shock. As this production requires from eight to ten-hundredths of a second, it is evident that if another stimulus be applied before the first has disappeared the two will coalesce; and when twenty per second reach the muscle it becomes permanently contracted or tetanised. By means of a very sensitive myograph, Marey has found that in voluntary contraction the motor nerves are the seats of successive acts, each of which produces an excitation of the muscle. In 1877, Marey examined similarly the discharge of the torpedo and found a most complete correspondence between it and muscular contraction. Since electric tension disappears from a muscle during contraction, does not the analogy suggest strongly that, like the discharge of the electric organ of the torpedo, muscular contraction is an electrical phenomenon?

Granting electric discharge to be a necessary concomitant of muscle-contraction, what is the origin of this electricity? That it is not carried to the muscle by the nerves follows from the fact that a muscle will still contract when deprived of all its nerve fibres, or when these are paralysed by curare. It must therefore be generated within the muscle itself. To reach a solution of the problem we must obviously follow the analogies of its production elsewhere.

Perhaps no single question in physics has been more keenly discussed than this one of the origin of electric charge. The memorable conflict between Galvani and Volta, between animal-electricity and the electricity of metallic contact, succeeded by the even more triumphant overthrow of the latter and the establishment ultimately by Faraday of the electro-chemical theory—these are facts fresh in all our memories. The justice of time, however, in this case, if it has been tardy, has been none the less sure. The experiments of Thomson have vindicated Volta and established the contact theory as a *vera causa*. And, more curiously still, it now appears to be proved that both contact and chemical action underlie the production of that very animal-electricity so stoutly battled for by Galvani and his associates.

Volta's experiments to prove that a difference of potential is developed by the contact of two heterogeneous metals were not crucial. But Thomson, repeating them with the aid of more delicate apparatus, has shown that whenever copper and zinc are brought in contact, the copper becomes negative to the zinc. In proof that the chemical action of atmospheric moisture was not the cause of the phenomenon, he showed that when a drop of water served to connect the copper and the zinc, no charge at all was produced. The fact may therefore be regarded as established, as the result of numerous and varied experiments, that a difference of electrical potential is always developed at the surfaces of contact of heterogeneous media. Not only is this true of solids in contact with solids, but also of solids in contact with liquids, and of liquids in contact with each other. Of course the production of electricity by contact must result from a loss of energy elsewhere. In the opinion of Cumming, it is the loss of energy which is owing to the unsymmetrical swinging of the molecules on the two sides of the surfaces of contact which reappears as difference of potential between the solids or as the energy of electrical separation.

But we may carry the sequence yet another step backward. The energy which is thus lost at the surfaces of separation must be heat, and this junction must be cooled thereby. Thus the production of thermo-electricity is seen only to be a special case of a general law, a view to which the well-known Peltier effect gives support. In this phenomenon, when two metals are joined together in the form of a ring and one junction is heated, a current is produced which cools the other junction. From a study of these conditions, Thomson has concluded that the absorption of heat in a thermo-electric circuit varies for different metals with the direction of the current. Thus in iron the current from hot to cold absorbs heat, while in copper the current which absorbs heat is from cold to hot. In entire accordance with these results are the conclusions recently reached by Hoorweg. Whenever two conductors come into contact, motion of heat results in the development of electricity, the current produced existing at the cost of heat at one part of the point of contact, and evolving heat at the other for a result. Hence, all voltaic currents are thermo-currents.

To return to the muscle, it must now be apparent that the electrical charge which appears in its fibre may have its origin in so purely a physical cause as the contact of the heterogeneous substances of which the tissue is built up; the maintenance of this charge being effected by chemical changes going on constantly in the substance of the muscle, by which

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the carbon dioxide is produced, which is shown to be a measure of the work done.

Conceding, then, that a muscular contraction is conditioned upon an electric discharge, by what mechanism is the contraction effected? Prevost and Dumas supposed each particle of a muscular fibril to be magnetic. Such a row of particles would, indeed, attract each other when magnetised, and shorten the length of the whole fibril. But the force of contraction would increase as the length diminished; whereas the fact in the case of the muscle is precisely the reverse. Hence Matteucci supposed that electrification of the muscular fibre produces a repulsion between its elements, the subsequent return of this fibre in virtue of its proper elasticity constituting the muscular contraction. Radcliffe's theory is of more recent date and is somewhat analagous. He maintains that each fibre of the muscle together with its sheaf constitutes a condenser. When charged, the attraction of the two electricities compresses the fibre laterally and thus elongates it. When discharge takes place the normal elasticity of the fibre produces the contraction. Assuming, however, that the electrical phenomena take place during the latent period only, other theories of muscular contraction regard these phenomena as simply preparatory, the contraction itself being mechanical. Thus Marez likens the muscular fibre to a string of india rubber, which, when stretched, contracts upon warming it; thus transforming heat directly into work. Rouget contends that the muscular fibre is a true spiral spring, which, actively distended during the repose of the muscle, returns upon itself at the moment of contraction; muscular contractility being thus a purely physical property of elasticity. Engelmann, observing that during contraction changes take place in the doubly-refracting power of the alternate discs of the fibril, supposes muscular contraction to result from a passage of water from the isotropic layers into the anisotropic or doubly-refracting ones, thus osmotically increasing the volume of the latter. By this means the ellipsoidal doubly-refracting particles are converted into spherical ones; and, since the longer axes of the ellipsoids are parallel to the length of the fibre, the muscle is thereby shortened.

From this brief review, does it not seem probable that the phenomenon of muscular contraction may be satisfactorily accounted for without the assumption of "vital irritability" so long invoked? May it not be conceded that the theory that muscular force has a purely physical origin is at least as probable as the vital theory?

Time would fail me to discuss the many other phenomena of the living body which have been found on investigation to be non-vital. Digestion, which Prout said it was impossible to believe was chemical, is now known to take place without the body as well as within it, and to result from non-vital ferments. Absorption is osmotic, and its selective power resides in the structure of the membrane and the diffusibility of the solution. Respiration is a purely chemical function. Oxyhæmoglobin is formed wherever hæmoglobin and oxygen come in contact, and the carbon dioxide of the serum exchanges with the oxygen of the air according to the law of gaseous diffusion. Circulation is the result of muscular effort both in the heart and the capillaries, and the flow which takes place is a simple hydraulic operation. Even coagulation, so tenaciously regarded as a vital process, has been shown to be purely chemical. Upon the hypothesis of Schmidt it results from the union of two proteids, fibrinogen and fibrinoplastic substance. According to the later theory of Hammarsten, fibrin is produced from fibrinogen by the action of a special ferment.

There is another function which should by no means be omitted from our consideration. This function is that of the nervous system. In structure this system is known to us all. In composition it is made up essentially of a single substance, discovered by Liebreich, and called protagon, the specific characters of which have lately been confirmed by Gamgee. In function the nerve cell and the nerve-fibre are occupied solely in the production, the reception, and the transmission of energy, which is believed to be electrical. There is evidently a close analogy between the nerve and the muscle, the nerve fibre, like the fibrilla, being composed of cells, and having a positive electric charge upon the exterior surface, the tension of which is one-tenth of a volt. Indeed, a piece of nerve removed from the body exhibits nearly the same electric phenomena as a piece of muscle. Haughton attributes *tinnitus aurium* to the vibration of nerve cells.

The main objection raised to the electrical character of nerve energy is based upon its slow propagation. Though thirty-six years ago Johannes Müller predicted that the velocity of nerve transmission never could be measured, yet Helmholtz accomplished the feat very soon afterward. His results, like those of subsequent experimenters, show that the velocity of propagation of the nervous influence along a nerve, like that of electric transmission, is only about 26 to 29 metres in a second. But it should be borne in mind, as Lovering has pointed out, that electricity has no velocity in any proper sense. That since the appearance of an electrical disturbance at the end of a conductor depends upon the production of a charge, the time of this appearance will be a joint function of the electrostatic capacity of the conductor and of its resistance. Since each of these values is directly proportional to length, it follows that the time of transmission will vary as the square of the length of the conductor. While, therefore, in Wheatstone's experiment, he found that electricity required rather more than one-millionth of a second to pass through one quarter of a mile of wire, it does not follow that it would traverse 288,000 miles in one second, as he assumed. Indeed, as Lovering has shown, its actual velocity would be only 268 miles in an entire second. Hence the marvellous discrepancies which have been observed in the results of experiments made to determine the velocity of electricity on long wires are explained.

In the nerve itself, therefore, the velocity of transmission may be supposed to be the less as its resistance is greater. Now, Weber has shown that animal tissues in general have a conductivity only one fifty-millionth of that of copper, and Radcliffe found that a single inch of the sciatic nerve of a frog measured 40,000 ohms; a resistance eight times that of the Atlantic cable. In experimenting to confirm the above law of velocity, Gaugain measured the time of transmission of the electric current through a cotton thread 1·65 metre long, and found it to be 11 seconds. Two similar threads placed consecutively, thus forming a conductor twice as long, required 44 seconds for the passage of the current; or four times as long. From these data the apparent velocity in the short thread is at the rate of only 0·15 metre in one second; and in the long one only about half this rate, of course. The real velocity in both cases is the same, 0·5 metre per second. Hence the fact that the energy of nerve moves at the rate of only 28 metres per second is really no proof that it is not electricity.

But even if it shall appear that the nervous energy is not electrical, the argument is not weakened, since on no theory yet proposed is it assumed to be vital. Du Bois Reymond, while maintaining that "it would be rash entirely to dismiss the notion of electricity being concerned, and even playing an important part, in the internal mechanism of the nerves," yet, assuming its low velocity to be fatal to its electrical character, suggests that the nervous agent "is some internal motion, perhaps even some chemical change of the substance itself, contained in the nerve tubes, spreading along the tubes both ways from any point where the equilibrium has been disturbed." And Spencer has advanced the view that "a nervous disturbance travels as a wave of molecular change," that "a nervous discharge is a wave of isomeric transformation."

Electric Lights for the Crystal Palace.—At the ordinary half-yearly general meeting of the Crystal Palace Company, held last week, the chairman, Mr. W. M'George, said that "They were considering the propriety of lighting the Palace by electricity. During the Wool Exhibition they had been obliged to buy steam engines, and they had the necessary power and nearly all the other appliances, except fixing the dynamos. They hoped, therefore, very soon to carry out that improvement."

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PRACTICAL TELEPHONY.

(CONTINUED FROM PAGE 303.)

SWITCH-BOARDS.—A few types of switch-boards will now be illustrated. The engraving below, Fig. 55, shows a 50 line switch

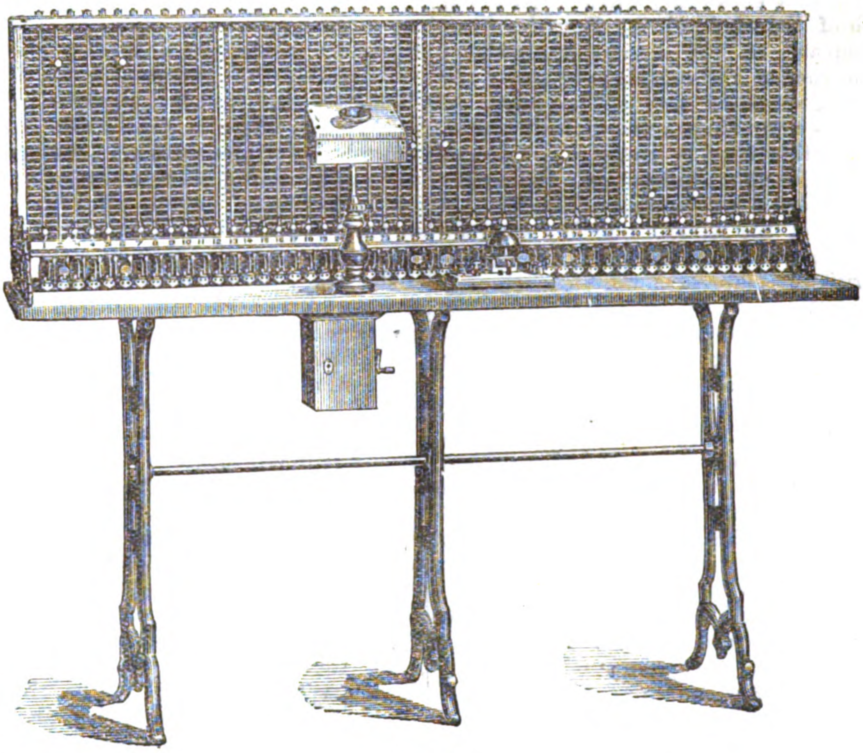

FIG. 55.

and indicator board fitted with transmitter, and a magneto generator for calling up subscribers. The annunciators are of the type shown in Fig. 56. The 50 vertical bars are in connection with the 50 subscribers' lines, any two of which can be connected by means

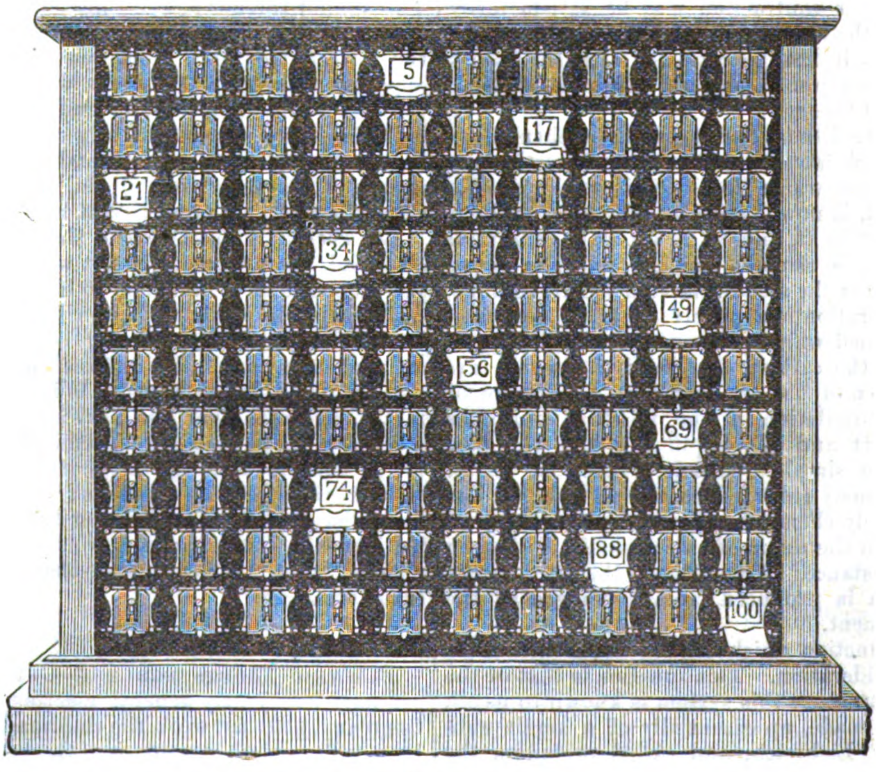

FIG 57.

of one of the numerous cross bars at the back of the vertical bars, the connection between the vertical and horizontal bars being made by means of the spring studs, which slide up or down the vertical bars.

SLIPPER SPRING SYSTEM.—The switch-board (Fig. 57) is a very compact form, 100 lines only occupying a space 20 by 24 inches and two inches deep. The indicator board can be placed upon or beside the switch-board (which is of the slipper spring type) or used by itself, the arrangement depending upon the requirements of the exchange. The details of the annunciators are shown in Figs. 58 and 59, and the details of the slippers, springs, jacks, &c., in Figs. 45, 46, and 48 (page 258, July 28).

SWITCH PLUG SYSTEM.—Fig. 60 shows this board; the annunciator drops, 24 in number, are placed over the switch-board, which consists of 24 vertical (representing the subscribers) and 12 horizontal strips, these latter being divided into four sections of three each, called A 1 2 3, B 1 2 3, C 1 2 3, D 1 2 3. Each board is connected to the one next it by wires reaching from

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several of the horizontal strips (one of which is connected with the operator's transmitter, ringing key, and telephone) to the

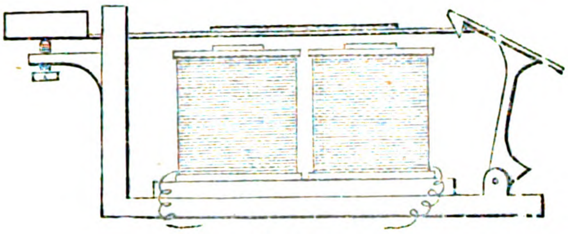

Fig. 56.

corresponding strip on the next board, and so on round the room, and as 12 strips will only allow of 12 sets of subscribers speaking

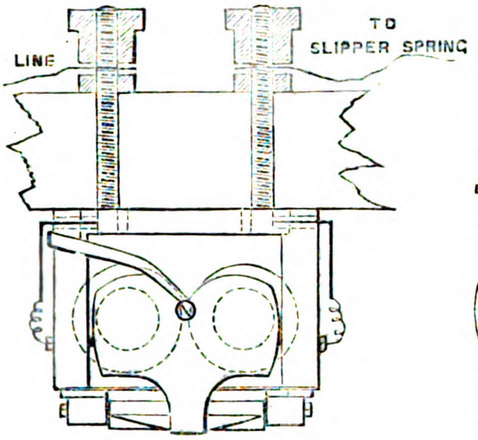

Fig. 58.

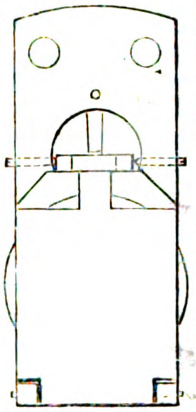

Fig. 62.

at once, provision is made to accommodate more by adding extra strip boards under the others; the vertical bars of the upper

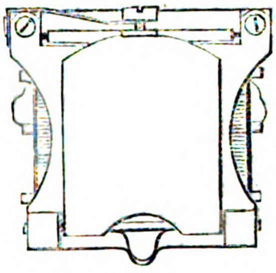

Fig. 59.

Fig. 61.

board being connected to the next board below by connecting wires. The sections of the next lower board would be called

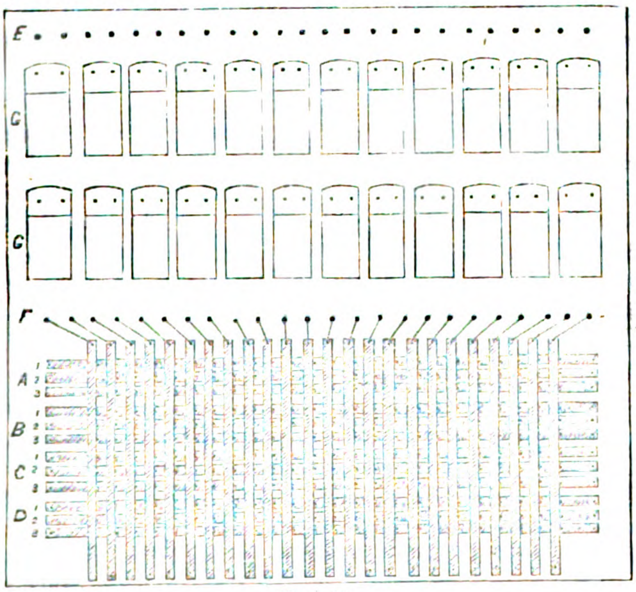

Fig. 60.

E.F.G.H., and so on according to the number of boards placed under the first. Each set of boards, attended to by one operator, has a table key, telephone, and transmitter, as mentioned above. The details of the strips are shown in Fig. 61, and the annunciator at Fig. 62. Each operator has usually 24 or 48 communicators to attend to. When a call arrives the operator places a peg into the hole connecting the subscriber with the operator's instrument, ringing the reply, and inquiring the number described. This being given, and the number is on the same board, a peg is put in each subscriber's vertical strip, so as to connect them to the same horizontal bar, any one that is disengaged being chosen. The operator then rings up, and when answered and the subscribers are in communication the peg connecting the operator's instrument is withdrawn. If, however, the subscriber asks for a number attended to by another operator, the first operator places the peg in connection with the subscriber's strip and, say, the fifth horizontal strip, down which is B 2. The first operator then calls to the operator having the subscriber required, and gives the number thus—134, B 2, meaning subscriber 134 connect to strip B 2. When this is done the subscribers are in communication.

(TO BE CONTINUED.)

CORRESPONDENCE.

MANCE'S BATTERY TEST.

TO THE EDITOR OF THE ELECTRICIAN.

Sir: I have to thank my friend and quondam fellow-pupil, Mr. Wilkinson, for his correction, in your issue of 21st July, of the evident "slip" in my late "note" on Mance's battery test.

Referring, once more, to Fig. 4 in your issue of 14th July, it is clear that:—

1. Since, with K closed, 10 only out of 10 + 9·09 = 19·09 parts of current influence G,

2. Seeing that 596·16 would be the value for D were G influenced by the whole, or 19·09 parts of current,

then the ratio of $\frac{19\cdot09 \text{ parts}}{10 \text{ parts}} = 1\cdot909$ becomes the value by which 596·16 must be divided in order to obtain actual value for D.

$$D = \frac{596\cdot16}{1\cdot909} = 312\cdot236, \text{ not (to strain at a gnat) } 312\cdot3.$$

—Yours, &c., Ed. R. Barker.

Madeira, 31st July, 1883.

SOUTH WALES INSTITUTE OF ENGINEERS.

TO THE EDITOR OF THE ELECTRICIAN.

Sir: Papers read at our meetings are not published without the council's permission, and as the members of this institute are not allowed to take notes for publication, it would be interesting to learn how you came by the extracts given on page 293 of your last number, and to know who furnished the information about the discussion which "showed clearly the dense ignorance."—Yours, &c.,

A Member.

London, 13th August, 1883.

[We do not think the information asked for would be "interesting" to anybody but our correspondent, and we are not disposed to gratify him.—Ed. *E.*]

EDUCATIONAL.

TO THE EDITOR OF THE ELECTRICIAN.

Sir: In reply to "Constant Reader's" letter in *The Electrician* of last week, I would draw his attention to the School of Telegraphy and Electrical Engineering, 12, Princes-street, Hanover-square, W., where I am sure he would be able to obtain all the knowledge he desires. I can speak from experience of the above-named institution, having been a pupil there myself.—Yours, &c.,

Aug. 13, 1883. F. F. Yeatman.

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THE ELECTRICIAN.

TO CORRESPONDENTS.

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ANSWER TO CORRESPONDENT.

A. BANDSEPT.—*Your letter on the "Transmission of Power" received. We shall hope to find room for it in our next issue.*

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IMPROVEMENTS IN SUBMARINE CABLE MANUFACTURE.

It is interesting now and then to cast a glance back at the gradual improvements that have been made in the manufacture of submarine cables, the conducting wires of which, as well as their insulating medium and outer protection, having undergone considerable modifications during the past ten or twenty years.

First, as regards the conductivity of the copper employed, we have no very precise data at hand as regards the conductivity of the very earliest lines, as they were not subjected to any accurate measurement, but there has been evidence that some of the copper employed on these lines had only a conductivity of about 50 per cent. of pure copper. In 1859 the first Malta and Alexandria cable had copper of a conductivity of 80 per cent. of pure copper. In 1862 the specification for the Persian Gulf cable gave 76 per cent. as the lowest conductivity allowed, and extra was to be paid for all copper supplied above 81 per cent., the mean obtained being 89·14. In 1864 Mr. Varley's specification for the Atlantic cable was 85 per cent. Since then the copper supplied has been 95 and even 98 per cent. of pure copper, and, indeed, some of the copper supplied has been so high as to give rise to a belief that the standards for pure copper are not altogether correct. In any case, it is almost certain that the copper employed at the present has about twice the conductivity of that used in the cables laid between 1850 and 1855.

As regards the form of the conductor, there have been one or two improvements. At first a single solid wire was used for a conductor. This frequently broke, the ends remaining in contact until a strain was applied, when they separated, and continuity was lost. A strand of several wires was then adopted, on the principle that all would not break at one place. The first cable of this kind was that laid between Cape Ray and Cape North in 1856, the solid conductors of the first cable attempted on this route in 1855 having parted during the paying out. There were objections to the strand, however; the interstices left air between the copper and the gutta percha, and this caused a difficulty in making joints at sea, the air being forced up by the pressure, and causing bubbles in the soft gutta percha applied at the joints. The application of Chatterton's compound to fill up the interstices to some extent has remedied this. It was also shown that theoretically the strand wire would have a greater electrostatic capacity for a given sectional area. In 1863 the conductor of the Persian Gulf cable was made of four pieces, having a section in the shape of a quadrant, surrounded by a fifth in the shape of a tube, the whole drawn down together to the proper size. It was believed that this would combine the advantages of a strand with those of a single wire. A want of continuity, however, occurred in one section, and the difficulty of making a joint arose in another. Since then the strand has been generally adopted, and the difficulty of jointing when it occurs can be overcome by clasps on the gutta percha, as invented by the late Mr. J. Laws, and applied successfully by him to the Persian Gulf cable; but we cannot say that we have heard much of this lately. Possibly the interstices between the copper and gutta percha are more solidly filled up. The advantage of strand over a single solid wire are evidently sufficient to counterbalance the slight disadvantage caused by its larger electrostatic capacity. The segmental wire has never been returned to.

On the Direct United States cable, however, another attempt was made to combine the advantage of strand with a smaller electrostatic capacity by placing a very large central wire, surrounded by a number of smaller wires, thus reducing the proportion between the external surface and the sectional area; but this plan has not been followed up, and most cables have strands of seven equal wires.

As regards the joints in the copper, these were at first scarfs, soldered and lapped round with fine wire, and again soldered throughout. Then they broke by a sharp bend wire, solder and fine wire all breaking together, as they formed one solid mass. Then the lapped wire was soldered at the two ends and the middle, and afterwards the central soldering was dispensed with, so that when the scarfs parted the spiral wire gave without breaking, and its two ends remaining soldered kept up the continuity.

As regards the gutta percha insulation, the improvements in its insulating properties by superior manufacture have been very great. The earliest cables had, perhaps, an insulation of about 10 or 20 megohms per nautical mile. The Red Sea cable of 1859 gave about 34 megohms at 75 degrees. The Malta and Alexandria cable of 1859 was specified to have 90 megohms at 75 degrees, but the average tests gave 125 to 135 megohms at that temperature. In 1863 the Persian Gulf cable was specified to give 109 megohms, but it reached 192·8, and some of its coils were from 241 to 399 megohms.

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Since then vast strides have been made. The Direct Spanish in 1872 gave 344 megohms at 75 degrees before shipment, and cables now often give 600 or 700, and even 800, megohms at 75 degrees.

The specific inductive capacity of gutta percha has also been much lessened, probably some 15 or 20 per cent.

India rubber covered wires were at first a complete failure, till Hooper produced samples that had a wonderful insulation resistance, giving about 6,000 megohms per mile, and many long lines were laid insulated with that material, including 500 miles in the Persian Gulf in 1869, which is still working. India rubber has not, however, been so extensively used of late. Henley's ozokerited india rubber core promises well, and deserves a trial on an extended scale.

The outer protection of cables has been considerably improved. The process of placing hemp and bitumen outside the sheathing, introduced by Mr. Latimer Clark, was first employed on the cable laid between the Isle of Man and the mainland in 1859, and this compound, in the shape of tape and bitumen, is now very perfectly applied. The wires of the Anglo-American Atlantic cables are now also separately covered with a material called "Clifford's Compound," which must add greatly to their life. The introduction of homogeneous iron adds some 60 per cent. to the strength of the deep sea cables over those made with iron as formerly used. We believe the 1865 Atlantic cable was the first cable on which the Homo wire was employed. In 1880 some ten miles of cable was made with steel wire having a tensile strength of 90 tons to the square inch. The adoption of strands in heavy shore ends was a great improvement on the solid wires, as broken solid wires are easily sucked up by anchors sliding along the cable.

The process of placing a thin armour of brass tape round the core in cables liable to attack from the teredo is also a step adding greatly to the general security of cables. Altogether, there has been a steady improvement in the material employed, in the manufacture, and in the design of submarine cables since the first cable was laid across the Straits of Dover in 1851, a cable which is still at work, and though it has often been broken and patched, it has, nevertheless, outlived a great many of its children.

LITERATURE.

A Physical Treatise on Electricity and Magnetism. By J. E. H. GORDON, B.A. (Cambs.). Second edition, revised, re-arranged, and enlarged. Two vols. [Sampson Low, Marston, Searle, and Rivington.]

When the first edition of this work appeared it was acknowledged to supply a want, and that the want was somewhat urgent will be seen from the fact that the second edition of an expensive work has long been called for—sooner, in fact, than was expected. There is one paragraph in the new preface we are glad to read, and trust the author, notwithstanding his being "fully occupied by engineering work," will find or make time to write the promised book. The paragraph referred to is as follows:—"The subject of electric lighting has now become so important that I felt it would be impossible to treat it satisfactorily in the space available in a treatise on general electrical science. I have therefore cut out the short chapter on it which appeared in the first edition, and am reserving what I have to say for a work specially devoted to electric lighting, which is now nearly complete, and which I hope shortly to publish." We have several books on the electric light which are crosses between a manufacturer's catalogue and an elementary school book on electricity, but not one written by a competent author since the great developments of the past five years, so that we gladly welcome this promise.

In noticing the work now before us we must not forget the author's aim, which, he says, "has been to give a complete account of such portions of electrical science as I am acquainted with, and at the same time to regard them from a physical as distinguished from a mathematical point of view." We should have described the work in another way, but of course the author knows best. We may, however, be permitted to hold and to state our opinion, which is, that the author, being familiar with the details and results of the extended experimental work of recent years, and seeing the bearing of these results upon electrical science, also the great difficulties in the way of students obtaining a knowledge of these investigations, determined to facilitate the work of students by giving a work which has as a principal feature the discussion of these experiments. The result is an excellent treatise, far better illustrated than any other work we know treating of electrical subjects in the English or any other language. This edition has been partially rewritten, rearranged, and extended. The principal extensions relate to the experiments of Tribe, Bjerkness, Stroh, De la Rue, Becquerel, &c. These new chapters are beautifully illustrated, especially that upon Mr. Tribe's electrolytic experiments, where "facsimiles of the beautiful copper deposits on silver plates" are given.

The whole subject is treated under the parts—Electrostatics, Magnetism, Electro-kinetics, and Electro-optics, sub-divided into fifty-two chapters. We can only now undertake to rapidly indicate the method of treatment, leaving criticism to the future. The author commences by discussing the ordinary statical experiments and the deductions obtained therefrom, accepting Maxwell's theory that "the forces are transmitted by a strain or distortion of the medium which fills the space between the electrified bodies," and relying upon the "ether" atmosphere to coincide with the requirements of such a medium. Various instruments used in this branch of electrical investigations are described and illustrated, when, as might be expected from the author having made it a special study, the question of specific inductive capacity is treated in a comprehensive manner, due consideration being given to the researches of Cavendish, Gibson and Barclay, Boltzmann, Schiller, Wüllner, Hopkinson, Ayrton and Perry, &c.

The commencement of Part II. (on Magnetism) deals with ordinary experiments and illustrating lines of magnetic force. Terrestrial magnetism and the instruments used in its investigation are next noticed, brief reference being made in Chapter XVII. to earth currents, a subject deserving of fuller treatment, and upon which there is an accumulated mass of material.

Part III. is perhaps the most important division of the work, dealing as it does with electricity in the state in which it is applied in the arts. Here, then, we find various forms of battery described. The experiments of Ayrton and Perry on "Contact Electricity," a term, we think, altogether misleading, are fully stated, and then the instruments used in this branch of research are described. It will be seen that the author explains his instruments, when and where he wants to use them. A short chapter is devoted to "Units," the practical units as agreed to at Paris, of which Congress the author was a member, being adopted. The whole of this part deserves special attention, whether it be the chapters devoted to measurement, to current, extra current, electrolysis, or the description of Tribe's, Adams's, Bjerness's, Stroh's, Tyndall's, Gordon's, De la Rue's, Spottiswoode's, Crookes's, &c., experiments. In the latter portion of this part, and especially so in Vol. II. of the work, the investigations are given almost wholly in the words of the author, the extracts being taken from the *Proceedings* of the various learned societies before whom the papers were originally read. We regret that the author has so curtly dismissed the subject of secondary batteries, though it be with a promise to discuss it further in the "forthcoming work on electric lighting."

The last division of the book is exceedingly interesting, and treats of the work of Faraday, Verdet, Maxwell, Gordon,

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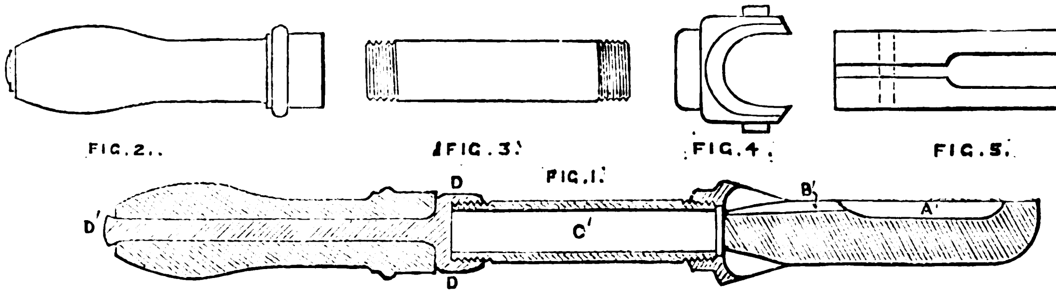
Kerr, Röntgen, Willoughby Smith, and others in the domain of electro-optics.

The time at our disposal has been all too short to do more than thus briefly refer to a book which every one emulous of the name of an electrician should possess. In it will be found information that can only be obtained by considerable trouble and searching through volumes of *Proceedings*, and even when a particular paper is found in the *Proceedings* its position in the "links" of research can never be so well ascertained as when found in the connected narrative given by Mr. Gordon in this treatise on electricity and magnetism.

A SOLDERING IRON FOR TELEGRAPH PURPOSES.

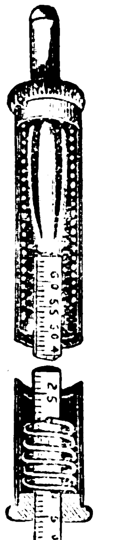
We herewith illustrate a soldering iron patented by Mr. J. O. Fry, to whom we are indebted for a description and drawings. Fig. 1 shows the arrangement. A′ is a well to receive the solder, into which the joint is dipped; B′ is a groove, by which the surplus solder is tipped into the cylinder C′, where it hardens into a stick for future use. DD′, the handle, unscrews, so that the solder stick can be taken out of cylinder. The other figures, showing the parts, explain themselves.



Fry's Soldering Iron.

TROUVÉ'S RHEOSTAT.

The following instrument was devised some years ago by M. G. Trouvé, the well-known electrician of Paris, but has only recently been described and illustrated in the columns of our contemporary, *La Nature*:—



It is composed of a german-silver spring, enclosed in a nickel-plated tube; the spirals are not allowed to touch each other, and are insulated from the tube by a sheathing of paste-board. Inside the spring is a rubbing contact of moderate elasticity formed by a metal rod split into four parts, slightly separated from one another.

The current arrives at the right hand side, traverses the spring, the contact, and the graduated rod. In the position shown in the illustration the rod is at the bottom, and the current only traverses a few spirals, the resistance introduced being very small. When, however, the rod is drawn out, the current, before it can reach the contact piece, has to traverse a more or less large number of spirals, and consequently a more or less considerable resistance. The divisions marked on the graduated rod correspond to the number of spirals included in the circuit.

This apparatus is used by M. Trouvé in connection with his polyscopes. It allows of regulation of the current furnished by a Planté accumulator, and the small platinum wire can be maintained at the required degree of incandescence in each particular case. The arrangement of the split elastic contact assures continuity of the regulation which operates at every quarter of a spiral, a sufficiently small fraction for practical purposes.

ELECTRO-MOTORS AND THEIR GOVERNMENT.*

BY PROFESSORS W. E. AYRTON, F.R.S., AND JOHN PERRY, M.E.

(CONTINUED FROM PAGE 308.)

The first improvement we made in governing consisted in replacing the "spasmodic governor" by a "periodic governor." With our "periodic governor" the power is never cut off entirely for any length of time; nor, on the other hand, is full power ever put on for any length of time, but in every revolution power is supplied during a portion of the revolution, the proportion of the time in every revolution during which much power is supplied to the time during which less is supplied depending on the amount of work the motor is doing. Our periodic governor, then, differs from the spasmodic governor in the same way that a good loaded steam-engine governor differs from the ordinary governor of a gas-engine. One of the ways of effecting this result is as follows:—A brush, A, Fig. 5, lies on the rotating-piece B K, the cylindric surface of which is formed of two conducting portions connected with one another through any resistance, and the brush A is moved along the cylinder B K, under the action of the governor balls. When the brush A is touching the contact part B, the motor is receiving current directly; but when A rests on the part K the motor receives current through the resistance which is interposed between B and K. If the governor balls fly out, the brush is moved along B K, so that there is contact with K during a greater part of the revolution than before; and if the governor balls come together, the speed of the motor being too small, the brush is moved in the opposite direction, so that it makes contact with B for a longer time during each revolution.

If the motors are in series, we arrange that the periodic governor shunts the currents periodically, instead of introducing resistance. In this case the connections are as follow:—

B is made of wood, while K is made of metal. K is connected to one end of a shunt coil, the other end of the shunt being connected to one of the terminals of the motor and A is connected to the other terminal of the motor. If, then, A rests on B, the shunt is inoperative, and all the current passes through the motor; whereas, if A rests on K, the shunt is in operation, and part of the current only passes through the motor.

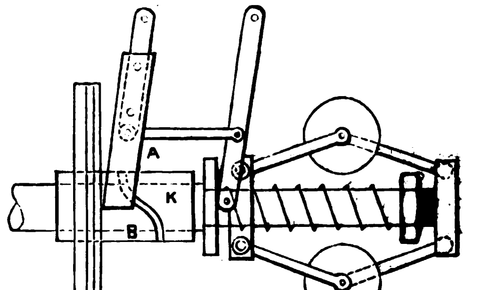


Fig 5.

We are fitting up one of our periodic governors to a Gramme machine working as a motor in series with accumulators—that is to say, a dynamo machine is employed to work the Gramme machine as a motor, and to charge the accumulators. When the motor is running too fast, all the current is, during the greater part of each revolution, shunted past the motor through the accumulators, and the current only passes through the motor during only a small portion of each revolution; whereas, when the motor is going more slowly, all the current passes through

* A Paper read before the Society of Telegraph Engineers, May 10, 1883.

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the motor during the greater part of each revolution before passing through the accumulators.

It is difficult with any such governors to entirely prevent sparking, and hence we prefer a totally different form of governor that we have devised, depending on the second system referred to above—that is to say, the employment of a brake, which brake stores up the superfluous power supplied to the motor. It is well known that if a dynamo machine be running empty, and its poles be closed, a great backward pull is exerted on the driving mechanism, in consequence of the dynamo machine now commencing to send a current and to do work; but not only will the closing of the circuit of a dynamo machine cause a pull to be put on the driving mechanism, but even a slight increase in the speed of a dynamo, the circuit of which remains unaltered, will also produce the same effect if the speed be the critical speed for the resistance through which the dynamo is sending a current, because this critical speed is that below

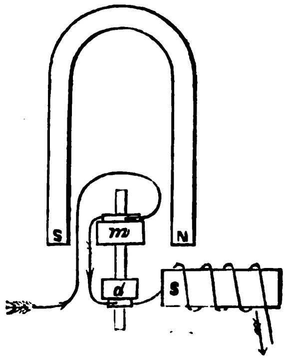

Fig. 6.

which but a small current is sent by the dynamo machine, and above which a great current is sent by the dynamo machine—that is to say, below the critical speed for any particular resistance the dynamo acts very feebly, while above that speed it acts as a powerful dynamo machine. Such a dynamo machine, then, with closed circuit, attached to the motor and driven by it, would act as a brake, and, if the normal speed of the motor was the critical speed of the dynamo for the particular resistance in its circuit, it would act as a very efficient brake, causing a great opposition to even a small increase of speed beyond that at which it was desired the motor should run at.

Hitherto we have spoken of the dynamo brake as if the electric power produced by it were wasted, but if it be in the same circuit as the motor, then the electric power produced by its rotation will help on the current, and the energy it absorbs in acting as a brake will not be subtracted from the energy of the whole system, but will merely diminish the speed of the particular motor

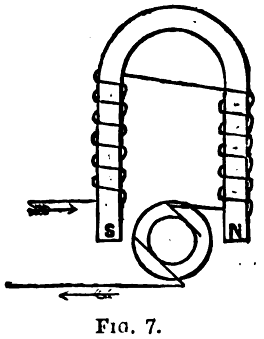

Fig. 7.

in question. Fig. 6 shows such an arrangement, in which a magneto-motor is geared with a small series dynamo—that is to say, the same spindle carries the armatures of both machines. The current passes through both the armatures in series, and then through the field magnet of the motor. In consequence of its passing through the armature, *m*, of the motor, the spindle is rotated, and a back electromotive force is set up, resisting the current, whereas the motion of the armature, *d*, of the dynamo sets up a forward electromotive force, and assists the current.

This combination of motor and generator brake is the gist of our method, and the exact combination we employ in any particular case depends on what are the supply conditions—that is to say, whether constant difference of potential is kept up at the terminals of the motor, or constant current is passing through the motors. When motors and lamps are in parallel circuit, then, in order that any one of them shall operate independently of all the others, it is necessary that constant difference of potentials shall be maintained between the supply leads; whereas, if they are in series, it is the current that must be kept constant to make the one apparatus which is consuming the electric energy independent in its action of the remainder. We have elsewhere described in detail the various methods we employ for obtaining constancy in the supply conditions in each of these two cases, and we shall assume in this question of governing motors that one or other of these supply conditions is kept constant.

1st. *When constant potential difference is maintained between the main supply leads.*

Fig. 6 is one of the arrangements that might be employed for governing the motor, and, although suitable enough for stationary motors, would have the disadvantage, if the motor had to be used for locomotion, that it contained two distinct machines. In practice, then, we prefer to replace the arrangement shown in Fig. 6 by that shown in Fig. 7 or 8.

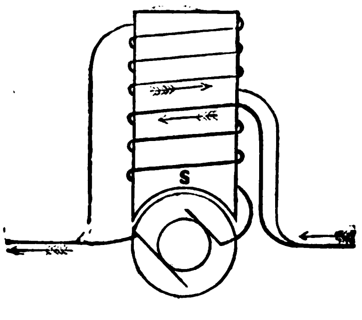

Fig. 8.

In Fig. 7 we have a magneto-motor, but, in addition, the wire forming part of the main circuit is coiled round the limbs of the permanent magnet in such a direction that the current passing through it weakens this permanent magnet. The result is that the armature and permanent magnet alone form a motor, whereas the armature and the coils of wire wound round the permanent magnet form a brake-dynamo. The current passing through the armature, acted on by the permanent magnet, produces motion, and hence is resisted, while the current passing through the armature and through the coils wound round the permanent magnet resists motion, and hence is assisted.

Fig. 8 differs only from Fig. 7 in that the permanent magnet is replaced by a shunt circuit, which it is easy to see it is possible to do if it be remembered that the supply condition we are dealing with is "constant difference of potentials at the terminals of the motor;" hence the current which passes through the shunt circuit will be a constant current, and the iron of the field-magnet, as far as this circuit is concerned, will act as a permanent magnet. The current then passing through the shunt circuit magnetises the field-magnet, as shown in the figure, but, in

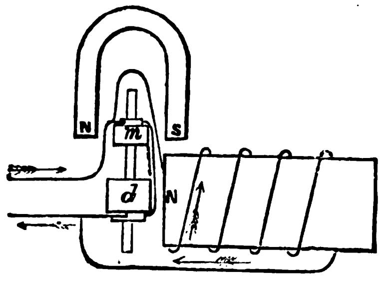

Fig. 9.

addition, the wire which forms part of the armature is wound round this field-magnet in such a way that the current passing through it tends to demagnetise the field-magnet, and here, as before, the armature and shunt circuit act as a motor, while the armature and the thick wire coil, which is a continuation of the armature, and which is wrapped round the field-magnet, form a brake-dynamo.

So far we have been dealing with motors in parallel circuit, with constant difference of potentials at their terminals. We will proceed to consider motors in series, and in that case the supply conditions will be—

2nd. *Constant current passing through all the motors.*

Here we may also combine two armatures working on a common spindle, as shown in Fig. 9, but in this case the magneto machine is a brake-generator; while the motor, which is the larger, is a shunt-motor, the field-magnet being a shunt to both armatures, which latter are in series.

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This double machine may be replaced by a coiled magneto-machine, as in Fig. 10, in which we have a magneto-generator acting as a brake and a shunt motor. Or, again, this may be replaced by the arrangement in Fig. 11, where the fine wire coil, which is a shunt to the armature only, acts with the armature as a motor; and the thick wire coil which forms part of the main circuit constitutes with the armature a brake-generator, so that the main current passing round this thick wire coil tends to demagnetise the field-magnet. Or, again, the shunt coil, which with the armature constitutes the motor, may be a shunt to both the armature and the demagnetising coil, as shown in Fig. 12.

The subject of governing motors may be mathematically investigated as follows:—

1. *When constant potential difference is maintained between the mains feeding motors in parallel circuit.*

Let the arrangement shown in Fig. 7 be that adopted, and consisting of a magneto motor and a series brake-dynamo.

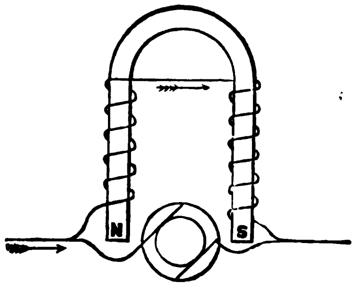

Fig. 10.

Let e be the back electromotive force set up in the motor when n is the number of revolutions per minute at which it is turning; let C be the current passing through it, then we know that

$$e = n\,(a - \mathrm{K\,C}),$$

where a is a constant depending on the permanent magnetism, and K on the coiling and the magnetic susceptibility of the steel magnet. But if E is the potential difference constantly maintained at the terminals of the motor, and R is the resistance of the armature and demagnetising coil combined, then

$$e = \mathrm{E} - \mathrm{R\,C},$$

but the total work the motor can do in consequence of its motion is

$$e\,\mathrm{C} = n\,(a - \mathrm{K\,C})\,\mathrm{C} = (\mathrm{E} - \mathrm{R\,C})\,\mathrm{C}.$$

which we desire to be able to vary at will without varying n.

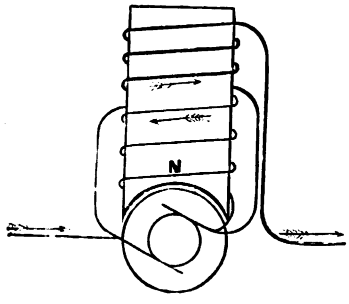

Fig. 11.

The second equation is therefore true for all values of C, which is the only variable, hence we must have

$$n\,a = \mathrm{E},$$
$$\text{and}\quad n\,\mathrm{K} = \mathrm{R}.$$

But if we consider the dynamo part alone, the approximate equation for the early part of its characteristic curve would be of the form

$$e_1 = n\,\mathrm{K\,C}.$$

Consequently, since one of the conditions for governing is

$$n\,\mathrm{K} = \mathrm{R},$$

we conclude that the resistance of the armature and demagnetising coil combined is such that it is the critical resistance of the dynamo part of the combination for that speed at which it is desired the motor shall always run, no matter what amount of work it may be doing.

To better explain this, we will take an actual case, and show how we experimentally determine the proper resistance to give to the governing demagnetising coil for any particular motor when the arrangement shown in Fig. 8 is employed.

Let f_1 be the resistance of the field-magnet of a series motor of any size and type, and a_1 the resistance of the armature. Pass a current, C_1, through the field-magnet only, and let e_1 be the electromotive force set up in the armature when it is rotated mechanically at a speed of n_1 revolutions per minute. If there be permanent magnetism in the field magnet, then two experiments must be made, in one of which the permanent magnetism of the field-magnet alone acts, while in the second both the permanent magnetism and the magnetism due to the current C_1 are combined, and e_1 then stands for the difference between the electromotive forces set up in the two experiments—that is, e^1 is the electromotive force due to the total magnetism produced by the current alone.

Then, if the field-magnet of the motor be rewound with two coils, one occupying $\frac{1}{x}$ of its volume, and having a resistance f_2, and the other $\frac{1}{y}$ of an equally useful part of its volume, and having a resistance f_3, and if a current, c, passes through the former, and c through the latter, the electromotive force e_2, set up in the armature coil, which, if rewound, may have a resistance a_2, will at n_2 revolutions per minute be

$$e_2 = \frac{e_1}{n_1\,\mathrm{C}_1\,\sqrt{a_1 f_1}}\,n_2\,\sqrt{a_2}\left(p + c\sqrt{\frac{f_2}{x}} + \mathrm{C}\sqrt{\frac{f_3}{y}}\right)$$

where p is the term due to the permanent magnetism which by definition is inoperative as far as e_1 is concerned, but is effective in producing e_2.

If the coil of resistance f_3, which is a continuation of the wire on the armature, as shown symbolically in Fig. 13, be so wound as to diminish the total magnetism in the field-magnet, the above equation reduces itself to the form

$$e_2 = n_2\,(s + tc - \mathrm{KC});$$

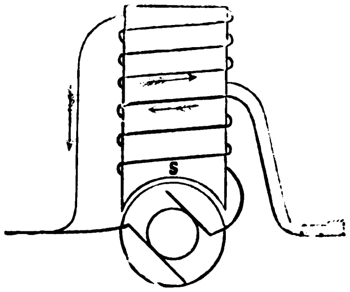

Fig. 12.

and, reasoning as before, we obtain for constant speed, independent of the work the motor may be doing, the conditions

$$n_2\,(s + tc) = \mathrm{E}$$
$$n_2\,\mathrm{K} = a_2 + f_3,$$

where f_3 is the resistance of the regulating coil.

To determine f_3, we have

$$f_3 = n_2\,\mathrm{K} - a_2$$

$$\text{and}\ \mathrm{K} = \frac{e_1}{n_1\,\mathrm{C}_1\sqrt{a_1 f_1}}\sqrt{\frac{a_2 f_3}{y}}$$

$$\therefore f_3 - \frac{n_2\,e_1}{n_1\,\mathrm{C}_1\sqrt{a_1 f_1}}\sqrt{\frac{a_2 f_3}{y}} + a_2 = 0$$

$$\therefore \sqrt{f_3} = \frac{\dfrac{n_2\,e_1}{n_1\,\mathrm{C}_1}\sqrt{\dfrac{a_2}{a_1 f_1 y}} + \sqrt{\dfrac{n_2^2\,\mathrm{E}_1^2}{n_1^2\,\mathrm{C}_1^2}\,\dfrac{a_2}{a_1 f_1 y} - 4\,a_2}}{2}$$

a_1, f_1 are the resistances of the armature and field-magnet of the motor as received for trial, and are therefore known. e_1 is the electromotive force the motor sets up when it is revolved at n revolutions per minute, and a current, C_1, sent through its field-magnet; e_1, n_1, and C_1 are therefore determined experimentally. y and a_2 depend on the rewinding; a_2 may be made equal to a_1 if we like—that is to say, the armature need not be rewound; y must be chosen judiciously, and its value is governed by the following considerations:—The presence of the governing coil diminishes the power of the motor, except when it is exerting its maximum power—not, however, by wasting the power, but by making the motor for the time being equivalent only to a smaller motor. Any form of governing an electric or any other motor must necessarily have this effect; for example, when a 20 horse-power steam engine is only turning the shafting of a factory, and doing no other work, the steam may be so much cut off by the governor that for the time being the engine may only be exerting 2 horse-power, which quite a small engine could, of course, just as well exert. As a matter of economy in weight,

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&c., it is not, of course, desirable to use a motor which is very much more powerful than is necessary, or, in other words, it is not desirable that the amount of governing should be necessarily very large; hence $\frac{1}{y}$ should not be too large. On the other hand, $\frac{1}{y}$ must not be too small, or the whole governing action will be too small, corresponding with a steam engine the governor of which has only a very limited range. Probably $\frac{1}{y} = \frac{1}{5}$ and $\frac{1}{x} = \frac{4}{5}$, that is, $y = 5$ and $x = \frac{5}{4}$, will generally give very good results, and those are the values we have employed in the one of our motors before you, which is thus governed by the combination of a shunt motor with a series brake-dynamo. $a_1, f_1, e_1, n_1, C_1, a_2$, and y having been thus determined, n_2 merely depends

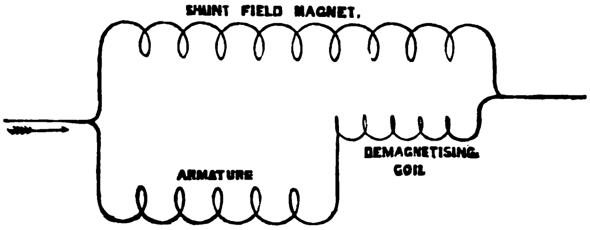

FIG. 13.

on the speed at which we desire the motor always to run, so that f_3, the resistance of the regulating coil, can now be found.

We will next consider the case

2. *When constant current is maintained through the motors.*

In Fig. 11 let a and f be the resistances of the armature and field-magnet respectively, A and F the currents passing through the armature and field-magnet, and C the total current which by

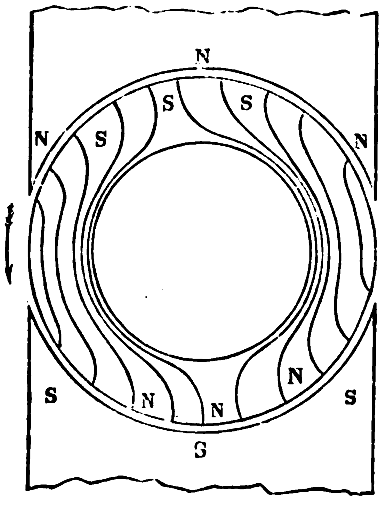

FIG. 15.

the supply conditions is kept constant; then, if e is the back electromotive force produced when the motor is running at n revolutions per minute,

$$e = n(p + q\,F - K\,C),$$

where p is a constant depending on the permanent magnetism in the field-magnet, q on the winding of the shunt coil, and K on the winding of the demagetising coil on the field-magnet.

But $$e = f\,F - a\,A,$$

$\therefore$ the total work the motor can do in consequence of its motion equals

$$e\,A = A\,n(p + q\,F - K\,C),$$
$$= A\,(f\,F - a\,A).$$

But $$F + A = C,$$

therefore, eleminating F, we have the total work equal to

$$A\,n\left\{p + q(C - A) - K\,C\right\} = A\left\{f(C - A) - a\,A\right\},$$

which we desire to be able to vary at will without varying n. Hence, as this equation must be true for all values of A, we must have the coefficients of A equal, as well as those of A^2, so that

$$f\,C = n\left\{p + (q - K)\,C\right\}$$
$$f + a = n\,q$$

are the conditions for governing when constant current is supplied to the motors. And the second of these means that the normal speed of the motor must be the critical speed for the motor when used as a shunt dynamo with an infinite resistance external to the machine.

If the shunt coil be a shunt to both the armature and the demagnetising coil, as shown in Figs. 12 and 13, then the equations become

$$e = n(p + q\,F - K\,A)$$
$$= f\,F - (a + r)\,A.$$

where r is the resistance of the demagnetising coil. Now, the first equation may be put into the form

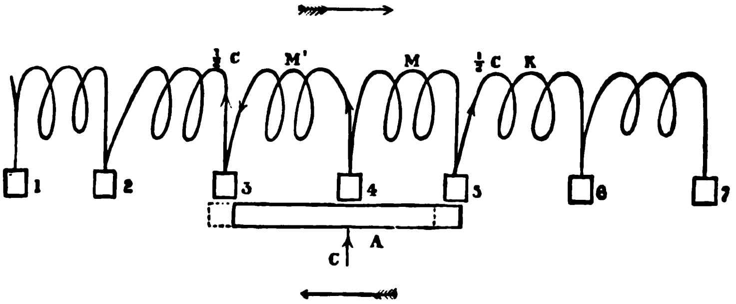

FIG. 14.

$$e = n\left\{p + (q + K)\,F - K\,C\right\},$$

therefore these equations are exactly like the two employed in the previous case, except that $q + K$ replaces q, and $a + r$ replaces a. Consequently, if these changes be made in the former equations for governing, we shall have the equations for governing applicable to this second case, which are therefore

$$f\,C = n\,(p + q\,C)$$
$$f + a + r = n\,(q + K).$$

And this second equation means that the speed at which it is desired the motor shall always run, independently of whatever work it may be doing, is the critical speed for the motor when used as a shunt dynamo when the resistance external to the motor is infinite.

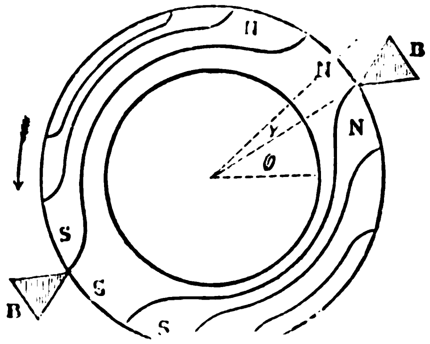

FIG. 16.

In both these cases, therefore, for constant current, n the normal speed of the motor is the speed at which the motor will begin to feed itself when used as a shunt dynamo, the external circuit being broken, but the connections in the motor itself left untouched.

In working out this theory we have, for simplicity, assumed—what is generally true in dynamos—that the magnetic field is mainly due to the action of the field-magnet. We will presently show why this is not the case in our motor, and why we believe it should not be the case in any good motor. But, although the difference in construction is very considerable, the formula employed in the mathematical investigation of the conditions for governing are similar to those we have employed, and consequently we have not thought it desirable to lengthen our paper by inserting them.

In the preceding we have also, for simplicity of calculation, assumed that the strength of the magnetic field produced by an electro-magnet is proportioned to the current passing round it, but this is, of course, only true when the magnet is far from saturation. A function, to express more accurately the strength

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of the field, must, of course, be such that for all very strong currents the field has a constant strength. Five years ago, Mr. Schwendler deduced, from his experiments on dynamo machines made at the India Store Department, that the equation connecting the electromotive force of a series dynamo, running at a particular speed, with the internal and external resistances was of the form

$$E = K \left\{ 1 - E^{-a\left(\frac{r}{r'}\right)^2} \right\}$$

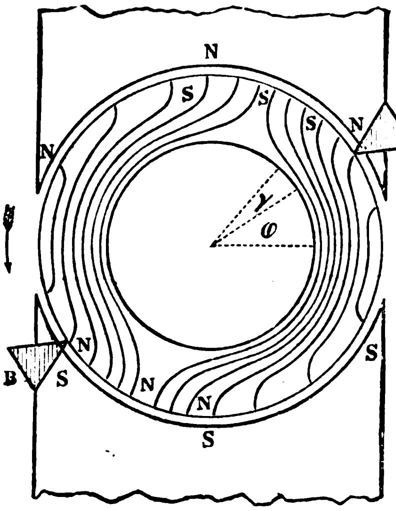

FIG. 16A.

where r is the resistance of the machine, r' the external resistance in circuit, and K and a constants. And one of us who had the good fortune to be assisting Mr. Schwendler in these investigations, in 1878, made at the time a large number of calculations to determine the most probable value of the constants in this function. Having, however, previously (when engaged with our students in Japan in putting into a convenient form for calculation some of the results given in Wiedemann's "Galvanismus," for the strength of an electro-magnet) employed the expression $\frac{k\,C}{1 + s\,C}$ for the strength of the magnetic field produced by a current, C, flowing round an electro-magnet, we saw that the equation for the curve connecting the electromotive force of a dynamo with the current flowing through its coils could be expressed in the form

$$E = n\left(p + \frac{k\,C}{1 + s\,C}\right),$$

where n is the speed, and p a constant depending on the permanent magnetism in the field magnets; and this formula, which it would naturally strike any practical mathematician to employ, we used then, and have ever since used in our calculations on dynamo machines and motors, and in our lectures to students. From this equation we were led theoretically, at the commencement of 1879, to the idea of critical speed in a dynamo; but finding shortly afterwards that the idea of a critical speed had been foreseen some years previously by Sir William Thomson, and that it was already referred to in the reprint of his papers on electricity and magnetism, we did not think it necessary to refer publicly to the results we had arrived at by the use of the above equation. We, however, now take this opportunity of alluding to the use of this equation for expressing the total electromotive force for a dynamo in terms of the current flowing through its coils, since in France, Germany, and England this equation has comparatively recently given rise to various claims as to priority of employment.

Another formula which we have also for some years been in the habit of using to express the strength of an electro-magnet in terms of the current flowing through its coils is,

$$a \tan.^{-1} b\,C,$$

but this does not lend itself so readily as the preceding to algebraical manipulation, or the theory of dynamo machines.

In the preceding investigation for governing motors we have, for simplicity, assumed that the resistance of the armature was a constant for a given temperature, but in reality this resistance depends on the number of reversals of magnetism in the coils of the armature per minute—that is, depends on the speed of rotation of the motor. That the resistance of the armature was not a constant was shown by M. Cabenallas in 1880*, but we are not aware that much attention has been paid to this very important fact in theoretical investigations of dynamo machines or motors, or that any attempt has been made to ascertain exactly how this increase of resistance depends on the speed of rotation and on the coefficient of self-induction. The calculation is comparatively simple, and is as follows :—

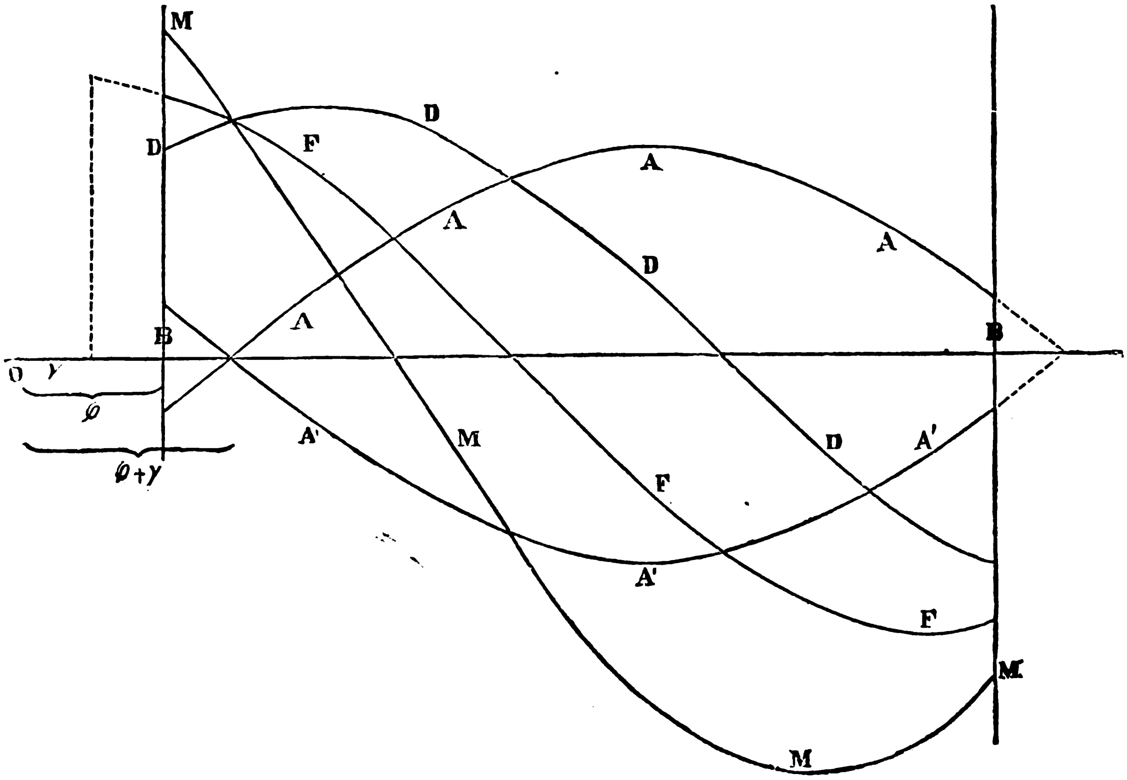

FIG. 17.

INCREASE OF RESISTANCE OF THE ARMATURE DUE TO SELF-INDUCTION.

Let M', Fig. 14, represent, symbolically, a coil just on the point of being short-circuited by the brush A. On the armature

* *Comptes Rendus*, Tome 90, No. 23, June 7th, 1880.

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moving in the direction of the upper arrow, as is the case in an ordinary dynamo or motor, or on the brush moving in the direction of the lower arrow, the armature being fixed, as is the case in our motor, the coil M, which previously had no current flowing in it, will now have a current $\frac{C}{2}$ started in it, whereas the coil M', which just previously had a current $\frac{C}{2}$ flowing in it, will be short-circuited. The result of this will be that, even if the brush be exactly in a neutral part of the field, so that there is no electromotive force in a short-circuited coil due to its cutting lines of force, still a certain amount of energy will be expended in starting the current $\frac{C}{2}$ in the coil M, and an exactly equal amount of energy will be wasted in the coil M' by the strong current momentarily induced in it on short-circuiting.

If l is the co-efficient of self-induction of the coil M, then the back electr motive force in it, due to starting the current $\frac{C}{2}$ in it, will be $\frac{1}{2}\ l\ \frac{dC}{dt}$, and the amount of energy thus expended, to be wasted when this coil is short-circuited at the next brush, is $\frac{1}{2}\ l\left(\frac{C}{2}\right)^2$ or $\frac{1}{2}\ l\,C^2$. Hence, the waste of energy due to one coil passing a brush, however many coils there may be short-circuited at a brush at any one time, is $\frac{1}{8}\ l\,C^2$, if the brush be in the neutral part of the field; or, if it be remembered that on a coil passing one brush, another coil symmetrically on the opposite side of the armature passes the other brush, the total loss of energy produced by the coil rotating through a circumferential distance equal to the breadth of one coil is $\frac{1}{4}\ l\,C^2$. Hence, if L is the co-efficient of self-induction per radian of the coil, and if n is the number of revolutions per minute, the loss of energy per second is

$$\frac{1}{4}\,L\,C^2 \times \frac{2\pi n}{60},$$

since $\frac{2\pi n}{60}$ is the angle turned through per second.

The waste of energy per second is consequently $\frac{\pi n L C^2}{120}$, and this corresponds with an increase in the resistance of the armature equal to $\frac{\pi n L}{120}$ ohms.*

The following gives a sample of the results our students have obtained when actually measuring the resistance of a fine wire Gramme ring rotating at different speeds in space at a distance from any iron except the iron wire composing its core, and traversed by a current which was kept constant in strength to avoid any change in the static resistance arising from changes in the heating of the wire by the passage of the current:—

Number of revolutions per minute.	Current in amperes traversing the Gramme ring.	Approximate.		
		Resistance in ohms.	Increase of resistance.	Equivalent back E.M.F. in volts.
0	·00488	1,768	...	...
670	,,	1,800	32	·156
825	,,	1,810	42	·209
1,050	,,	1,900	132	·642
1,300	,,	1,920	152	·744
1,490	,,	1,995	227	1·15
1,770	,,	2,060	292	1·42
2,230	,,	2,200	432	2·12

A number of sets of experiments similar to the above were made, and all led to the same result—that the resistance increases more rapidly than the speed, instead of the increase being proportional to the speed, as might have been expected from our reasoning on self-induction just given. Since the reading the paper, however, the main cause of this apparent discrepancy between theory and practice has been discovered, and is as follows:—In order to eliminate the effect of the earth's magnetism setting up an electromotive force in the rotating bobbin, the brushes were so placed on the commutator that when the bobbin was rotated at a particular speed no electromotive force was set up due to the earth. But in reality such an adjustment of the brushes must be made for every speed, unless the axis of rotation of the bobbin is that of the dip, since the magnetic poles induced in the iron of the bobbin are carried forward by the rotation, and are carried forward the more the greater the speed. In spite, therefore, of the careful adjustment of the brushes in obtaining the results, a sample of which is given above, it was only at one particular speed that there was no electromotive force due to the earth; at all speeds below this the electromotive force was assisting the current used for testing, and at all speeds above this it was opposing this current, thus making the increase of resistance too small at low speeds, and too large at the high.

To eliminate the error produced by the shifting of the poles by rotation, without resorting to the very troublesome operation of adjusting the brushes for each speed, we have in all our later experiments taken readings with both a positive and a negative current at each speed, and the following is a sample of the more accurate results thus obtained, the resistance of the Gramme ring at rest being 1,860 ohms:—

Revolutions per minute.	Increase of resistance.		Mean increase of resistance.	Increase of resistance calculated from $\frac{\pi n L}{120}$.
	+ Current.	− Current.		
600	70	50	60	75
800	110	75	92	100
1,000	150	90	120	125
1,205	200	110	155	150
1,400	245	130	187	175
1.602	320	120	220	200
1,806	405	150	277	212
2,000	480	190	335	250

Here the increase of resistance is far more nearly proportional to the speed than before, and, what is still more interesting, is approximately what is obtained by using the formula $\frac{\pi n L}{120}$, given above, up to speeds of about 1,600 revolutions per minute. For experiments made to determine the coefficient of self-induction by the Wheatstone bridge method, described by Clerk Maxwell, showed that it was about 7·5 ohms. The last column above shows the increase of resistance calculated from the expression $\frac{\pi n L}{120}$, using this value for L.

In addition to this increase of resistance due to self-induction, there is, as explained further on, a back electromotive force set up by the magnetic poles formed in the Gramme ring by the testing current not being at the brushes themselves, but, instead, carried forward by the rotation; and it is possible that this electromotive force, not being proportional to the speed, is the reason why the total increase in the resistance is not strictly proportional to speed, or it may be that at the very high speeds there is a slight jumping of the brushes. The real cause we are now endeavouring to ascertain experimentally.

In the preceding we have spoken of the armature as moving in ordinary motors, and the armature as fixed in ours. To make this quite clear, we may mention that we define the "armature," whether movable or fixed, of a continuous current dynamo or motor as that part of the machine in which the current is being perpetually reversed as the machine works; and the "field-magnet," whether fixed or movable, as that part round which the current is always flowing in the same direction.

Resultant Magnetic Field, and the Proper Lead to give to the Brushes in a Dynamo and in a Motor.

In an actual dynamo machine or motor, in addition to this practical increase in the resistance arising from self-induction, the power of the machine will be affected—

1st. By the magnetic field due to the field-magnet being rotated, and therefore weakened, by the rotation of the armature.

2nd. By the magnetic field due to the current in the armature being added to that due to the field-magnet.

3rd. By an actual back electromotive force set up in the armature of a dynamo, for the reasons to be explained further on.

It has usually been assumed that the magnetic field produced by the current flowing round the armature must, both in a

* Since presenting this paper we have learnt that a somewhat similar calculation has been recently made by M. Joubert, and his calculation will be found in the *Comptes Rendus*, Tome 96, No. 10, for March 5th of this year; but M. Joubert's result is not expressed in the simple form of an increased resistance of the armature as we have here expressed it.

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dynamo and in a motor, weaken the one set up by the field-magnet. It has further been assumed that, since a forward lead is given to the brushes in a dynamo on account of the delay in the magnetisation, that therefore a backward lead ought to be given to the brushes in a motor to give time for the current to magnetise the iron of the armature. And lastly, it has been taken for granted, that because, in both a dynamo and in a motor, the motion of the armature and field-magnet relatively to one another produces an electromotive force, therefore, since experience had shown that a powerful field-magnet and an armature of a com-

number of windings in the field-magnet and armature respectively, then F + A represents the total number of lines of force in the field, or what we may call the total strength of the field when the brushes have 90° of lead, and the armature and field-magnet are at rest. With any other lead, F will remain the same, but A will be reduced. Both F and A may be expressed in the form $\frac{k\,C}{1 + s\,C}$.

If the armature and field magnets are rotating relatively to

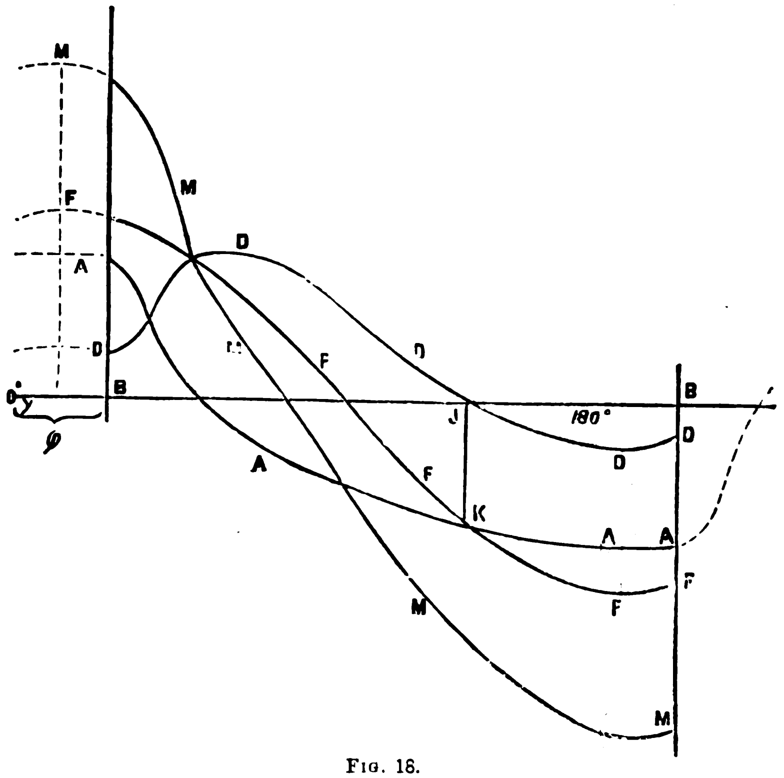

Fig. 18.

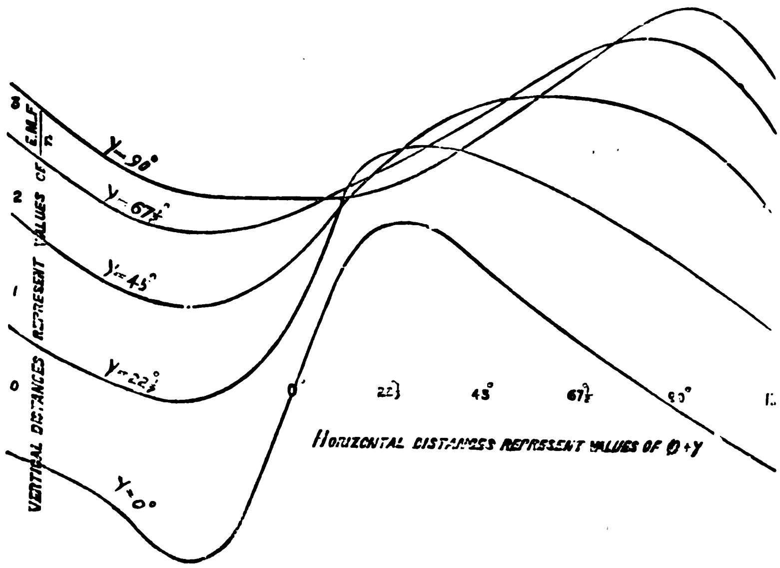

Fig. 20.

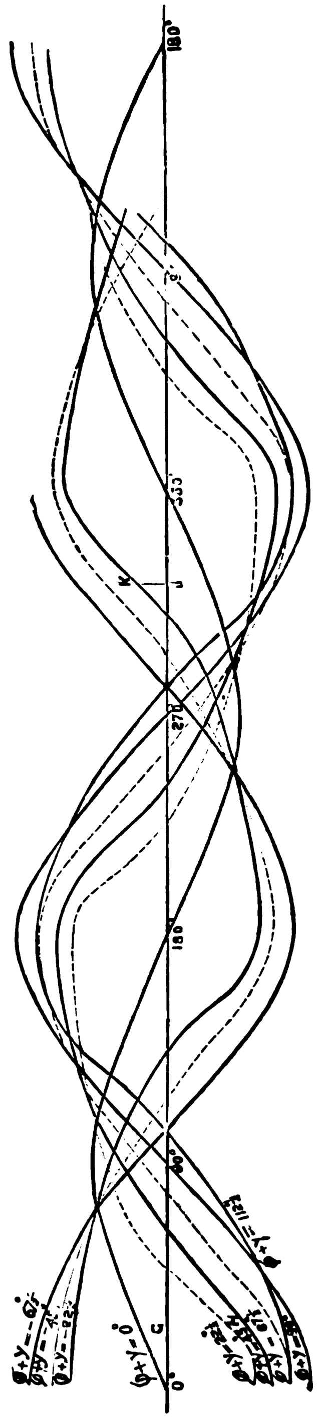

Fig. 19.

paratively weak magnetic moment were the best for producing a large electromotive force in a dynamo, the same proportion of field-magnet and armature must be the best to produce a powerful motor. As these three assumptions appeared to us unproved, we have thought it desirable to investigate what ought to be the relative strength of the magnetic fields produced by the field-magnet and by the armature in a motor.

In considering the strength of the field produced between field-magnet and armature by the field-magnet and armature currents respectively, if F and A are certain functions of the currents and

one another, then the field due to the field magnet will be twisted round, and consequently weakened.

Fig. 15 shows approximately, in the case of a Gramme machine, the distribution of the lines of force due to the field magnet as twisted round by the rotation of the armature.

If, now, θ is the angular distance from the position of a brush when there is no lead, then the number of lines of force passing through a coil of the armature at any place due to the field magnet alone is proportional to

$$f(n)\,F\cos.\,(\theta - \gamma).$$

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where γ is a function of n, the number of revolutions per minute. It seems, from the results of such experiments as have hitherto been made, that $f(n)$ and γ are nearly constant for small values of n, and diminish the more rapidly as n becomes considerable. The shapes of these functions vary with the shape of the armature and the nature of the iron. It is, of course, obvious that, instead of the simple periodic function cos. $(\theta - \gamma)$, we ought to employ a Fourier series to express the condition of a particular machine, a very important term in this series having a periodicity defined by the number of coils on the armature if any iron protrudes between the coils. But for general purposes the simple form is sufficiently correct. Now, if the brushes have a lead, ϕ, in the direction of motion, it is obvious that the electromotive force due to rotation will be proportional to

$$n\,W' f(n)\ F\cos.(\phi - \gamma),$$

where W' is the number of windings on the armature, since, as the distribution of lines of force at each brush is symmetrical, the electromotive force due to rotation must be proportional to the number of lines of force cutting a ring at a brush—that is, must be proportional to the value of the last expression, when θ equals ϕ.

If the field produced by the current flowing round the armature were symmetrical, and not affected by the iron of the field-magnet, as it is often erroneously supposed to be, and if it were merely twisted round by rotation, as shown in Fig. 16, then the number of lines of force passing through a coil of the armature at any place due to the current in the armature alone would be proportional to

$$+ f(n)\ A\sin.(\theta - \phi - \gamma);$$

and, as before, the electromotive force arising from the rotation of the coils in this field would be proportional to the value of this last expression, when θ equals ϕ, or to

$$- n\ W' f(n)\ A\sin.\gamma.$$

In the case of a dynamo machine, the resultant magnetic field is usually supposed to be due to the fields shown in Fig. 15 and in Fig. 16, for which latter case the sign of the last expression is, as stated, negative. In a motor, as we shall show further on, the field due to the armature may assist that due to the field-magnet, so that the distribution of lines of force due to the armature shown in Fig. 16 may be adopted, and in that case the number of lines of force passing through a coil of the armature at any place due to the current in the armature alone would be proportional to

$$-f(n)\ A\sin.(\theta - \phi - \gamma),$$

and the electromotive force arising from the rotation of the coils in this field would be proportional to

$$+ n\ W' f(n)\ A\sin.\gamma.$$

Hence, if the field due to the armature were a symmetrical field, the poles being at the brushes when the armature is at rest and only slightly shifted round by the rotation, as shown in Figs. 15 and 16, then in a dynamo machine the electromotive force would be proportional to

$$n\,f(n)\ W' \left\{ F\cos.(\phi - \gamma) - A\sin.\gamma \right\},$$

and in a motor to

$$n\,f(n)\ W' \left\{ F.\cos.(\phi - \gamma) + A\sin.\gamma \right\}.$$

In Fig. 17, B B is the development of the centre line of the ring from brush to brush. The curve F shows by its ordinates the number of lines of force passing through the armature coils at every part of the ring, due to the field-magnet action only; the curve A shows the same thing in the case of the dynamo, and A' in the case of the motor, for the armature magnetic action only. D shows the sum of F and A for a dynamo, and M the sum of F and A' for a motor. The electromotive force in the case of a dynamo will be proportional to 2 B D, and in a motor to 2 B M.

We have already stated that we do not recognise the assumption usually made that the armature field must weaken the field-magnet field in a motor as it does in a dynamo; but if the lead of the brushes in a motor is sufficiently far back, then the armature field will no doubt weaken the field-magnet field, as in the case of a dynamo, and the negative sign above must be taken.

To illustrate this, here is one of our motors so arranged that the wires passing round the field-magnet can be short-circuited, in which case the magnetism in the field-magnet will only be that produced by the induction of the armature. The lead of the brushes is put back so that the armature field weakens the field-magnet field, as in an ordinary dynamo. Now observe what happens. On starting the current the motor works as an ordinary motor, but on merely short-circuiting the field-magnet coils it stops, and rotates nearly as forcibly in the opposite direction. When the current then passed through the field-magnet there were strong negative forces opposing the motion, but which were overcome by the current passing through the field-magnet coils. The resultant action, therefore, was a difference, and consequently small. Now let us turn the brushes so as to give a more forward lead; the two actions help one another; the resultant is a sum, and the motor works more vigorously.

Although the adding together of the magnetic fields in motors is thus produced by a forward lead of the brushes, it may be possible in some cases that, owing to the iron of the armature being very hard, γ is so large that a backward lead of the brushes in a motor may produce an addition of the magnetic fields corresponding with a positive sign in the expression for the electromotive force. But under such circumstances $f(n)$ will be small, as rapid rotation will seriously diminish the magnetic moment produced by the current. In all cases, however, what has to be aimed at in a motor is the adding together of the magnetic fields produced by the field-magnet and by the armature.

We cannot lay too much stress on the importance of this fact—a motor must work mainly by attractive forces, and not by repulsive forces. The magnetic fields due to the field-magnet and armature must help one another, and not oppose one another, as in the case of a dynamo.

Distortion Produced by the Iron of the Field-Magnets of the Field due to the Armature.

When an ordinary dynamo machine is used as a motor, the attractive forces due to induction of the armature on the poles of the field-magnet are small, but in these motors of ours they are large, since the magnetic moment due to the armature coiling is large; and we wish to show that in an efficient motor the attractive forces ought to be made large, whereas in a dynamo they ought to be small.

In fact, in making any calculations from the distribution of lines of force, we must remember that not only does the iron in the armature determine the distribution of the lines of force due to the field-magnet, but that the iron in the field-magnet affects the distribution of the lines of force due to the armature. Indeed, as shown in Fig. 16A, the field due to the armature is by no means the same in the four quarters of the ring. The polar extensions of the field-magnet cause the intense part of the field to be at N and S, instead of at the brushes B B; and not only is the field twisted round, but we have on one side of N or of S a more sudden diminution of the field strength than on the other side. In fact, instead of the curve of cosines, we have the curve shown in A, Fig. 17. Combining this with the field-magnet distribution given already, and represented in F, Fig. 18, we have the sum of these shown at M as the distribution for a motor, and the difference shown at D for a dynamo machine.

The electromotive force in a dynamo is therefore proportional to 2 B D, and in a motor to 2 B M.

Generalising roughly, for all shapes of machines it may be said that, whilst the electromotive force due to the rotation remains what it was before for the field-magnet distribution, viz., $n\ W' f(n)\cos.(\phi - \gamma)$, it assumes a different form for the armature from that previously obtained.

In the previous case, when the action of the iron of the field-magnets on the armature field was neglected, it was easy to express the equation for the curve A A A, Fig. 17, in terms of θ, ϕ, and γ, and from this, by making θ equal to ϕ, to find the expression for the electromotive force due to the armature field. But in the second case, when the disturbing action of the soft iron of the field-magnets is taken into account, we cannot from the one curve A A A, Fig. 18, express its equation in terms of θ, ϕ, and γ, seeing that the one curve alone gives no indication of how its form varies with changes in ϕ and γ. We have therefore in Fig. 19 drawn the curve A A A for various values of $\phi + \gamma$, equal respectively to $-67\tfrac{1}{2}^\circ$, -45°, $-22\tfrac{1}{2}^\circ$, 0°, $22\tfrac{1}{2}^\circ$, 45°, $67\tfrac{1}{2}^\circ$, 90°, $112\tfrac{1}{2}^\circ$.

As before, the horizontal line represents the development of the centre line of the ring, and the ordinates of any particular curve the number of lines of force due to the armature field as affected by rotation and by the presence of the iron of the field-magnets which pass through a coil on the armature at any angular distance, θ, from the original of that value of $\phi + \gamma$ for which the particular curve has been selected.

From these curves in Fig. 19, by giving to γ the values 0°, $22\tfrac{1}{2}^\circ$, 45°, $67\tfrac{1}{2}^\circ$, and 90°, we have calculated numbers proportional to the respective electromotive forces due to the rotated and distorted armature field divided by the speed of rotation. This we have done by measuring the ordinate which in each case for each curve corresponds with the position of the brush. For instance, to find the $\frac{\text{E.M.F.}}{n}$ when $\phi + \gamma$ equals 45° and γ equals $22\tfrac{1}{2}^\circ$, we must first select the curve corresponding with $\phi + \gamma$, equal to 45°; next we see that the brush which has the lead ϕ or $(\phi + \gamma) - \gamma$ is really at $22\tfrac{1}{2}^\circ$ from the zero. Hence G H is pro-

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portional to the $\frac{\text{E.M.F.}}{n}$ in this case. The following table gives all the results so obtained :—

$\phi - \gamma$.	E.M.F. $\div\, n$ for the following values of γ.				
	$\gamma = 0$.	$\gamma = 22\frac{1}{2}°$.	$\gamma = 45°$.	$\gamma = 67\frac{1}{2}°$.	$\gamma = 90°$.
$-67\frac{1}{2}°$	$-0·62$	0·67	1·87	2·75	3·33
-45	$-1·00$	0·12	1·12	1·92	2·46
$-22\frac{1}{2}$	$-1·79$	0·12	0·87	1·57	2·00
0	0	0·72	1·33	1·83	2·00
$22\frac{1}{2}$	1·75	2·50	2·47	2·33	2·00
45	1·01	2·42	3·00	2·83	2·75
$67\frac{1}{2}$	0·58	1·88	3·04	3·50	3·29
90	0	1·46	2·75	3·62	4·00
$112\frac{1}{2}$	$-0·77$	0·67	1·83	2·67	3·22

From these numbers we have drawn curves shown in Fig. 20, connecting $\phi + \gamma$ and $\frac{\text{E.M.F.}}{n}$ for each of the values of γ; and, finally, from these latter curves we find that the electromotive force due to the rotation of the coils in the armature field, as twisted by rotation and distorted by the iron of the field-magnets, is proportional to

$$(1 + 0·8 \cos. \gamma) \sin. 2 (\phi + \tfrac{1}{2} \gamma) + 0·5 \cos. 2 \gamma \sin. 4 (\phi + \tfrac{1}{2} \gamma) + 3 \sin. \gamma,$$

Now as to the scale of these diagrams, it will be seen from what has gone before that $\frac{1}{2}$ A is to be used to express the greatest number of lines of force passing through any part of the armature when ϕ equals 90° and γ equals 0°, and, according to our scale of measurement employed in the diagrams above, A equals 4.

or, finally, that the total electromotive force in a dynamo or motor due to all causes is

$$n\, f(n)\, W' \left[F \cos. (\phi - \gamma) \mp \frac{A}{4} \left\{ (1 + 0·8 \cos. \gamma) \sin. 2 (\phi + \tfrac{1}{2} \gamma) + 0·5 \cos. 2 \gamma \sin. 4 (\phi + \tfrac{1}{2} \gamma) + 3 \sin. \gamma \right\} \right],$$

the negative sign being taken for a dynamo, and the positive sign for a motor. For the numbers 0·8 and 0·5 and 3 in this expression, literal co-efficients may be applied to express the general condition.

This expression, although complicated in appearance, will be found very useful, since it takes into account all the disturbing action arising from the action of the iron of the rotating armature on the field due to the field-magnet, as well as the disturbing action of the iron of the field-magnet on the field set up by the current flowing round the rotating armature.

(TO BE CONTINUED.)

A HISTORY OF ELECTRIC TELEGRAPHY TO THE YEAR 1837.

BY J. J. FAHIE, MEMB. SOC. TEL. ENGS. AND ELECS.*

(CONTINUED FROM PAGE 307.)

CHAPTER III.—TELEGRAPHS BASED ON STATIC, OR FRICTIONAL, ELECTRICITY.

1787.—LOMOND'S TELEGRAPH.

The next plan that we have to notice was a decided improvement, and had an actual existence, though on a very small scale. Seeing, no doubt, the difficulty and expense of using many wires, Lomond of Paris reduced, at one sweep, the number to one, and thus produced a really serviceable telegraph. Arthur Young, the diligent writer on natural and industrial resources, saw this apparatus in action during his first visit to Paris, and thus describes it in his journal, under date October 16, 1787 :—

"In the evening to M. Lomond, a very ingenious and inventive mechanic, who has made an improvement of the jenny for spinning cotton; common machines are said to make too hard a thread for certain fabrics, but this forms it loose and spongy. In electricity he has made a remarkable discovery. You write two, or three, words on a paper; he takes it with him into a room and turns a machine, enclosed in a cylindrical case, at the top of which is an electrometer, a small fine pith-ball*; a wire connects with a similar cylinder and electrometer in a distant apartment, and his wife, by remarking the corresponding motions of the ball, writes down the words they indicate, from which it appears that he has formed an alphabet of motions. As the length of the wire makes no difference in the effect, a correspondence might be carried on at any distance; within and without a besieged town for instance, or for a purpose much more worthy, and a thousand times more harmless—between two lovers prohibited, or prevented, from any better connection. Whatever the use may be, the invention is beautiful. Mons. Lomond has made many other curious machines, all the entire work of his own hands. Mechanical invention seems to be in him a natural propensity."†

As in all systems where the signals were indicated by electroscopes, or electrometers, their action would continue so long as the charge communicated to the wires lasted, and, as during this time it would not be possible to make another signal, the authors must in some way have discharged the wires after every signal, so as to allow the balls, gold leaves, or other indicators, to resume their normal position. This they might have done, either by touching the wires with the finger after the signal had been noted, or by making the indicators themselves strike against some body that would convey their charges to earth. But, probably, there was no need for any such stratagem, as the insulation of the wires would be so imperfect, and the speed of signalling so slow, that the inconvenience would not have been felt.

1790.—CHAPPE'S TELEGRAPH.

Most of our readers have, doubtless, heard of Claude Chappe's Semaphore, or Optico-mechanical Telegraph, which, in one form or another (for, like all successful inventions, it had many imitators), did such good service in the first half of this century. Few, however, are aware that, before deciding on this form of instrument, he essayed the employment of electricity for telegraphic purposes.

Reserving a full account of Claude Chappe's life and works for its proper place in a General History of Telegraphy, which we are about to publish, and of which these articles are destined to form a part, we need only concern ourselves here with a brief reference to his early experiments.

In 1790, he conceived the idea of a telegraph. He first employed two clocks, marking seconds, in combination with sound signals, which were produced by striking on that homely utensil, a stewpan (*casserole*). Round the seconds' dials were marked off equal spaces corresponding to the numerals 1 to 9, and the cipher 0. The clocks being so regulated that the second hands moved in unison, pointing to the same figures at the same instant, it is clear that, in order to indicate any particular figure, Chappe had only to strike the stewpan the moment the hand of his dial entered the space occupied by that figure; his correspondent, hearing the sound, must necessarily note the same symbol; and, so, successive figures, or groups of figures, answering to words and phrases in a vocabulary, could be indicated with great ease and rapidity.

But as sound travels so comparatively slowly, it would in long distances lag behind, and indicate, it may be, only an A, or B, when an E, or G, was intended. Under these circumstances it was but natural that Chappe should bethink himself of electricity, of which he was a diligent student, and on which he had just communicated a series of papers to the *Journal de Physique* (which, by the way, obtained his election as a member of the Philomathic Society).

He erected insulated wires for a certain distance,‡ and arranged that the discharge of a Leyden jar should indicate the precise moment for noting the position of the hands; but while he was thus removing one difficulty he found himself introducing another, viz., one of electrical insulation. The more he extended his wires the greater, of course, his difficulty became, until in despair he abandoned the use of electricity, and took to that of optico-mechanics.

In the actual state of telegraphy this circumstance becomes an interesting one, for Chappe held in his hands a power which was destined soon, under another form, to demolish the grand

* The author reserves all rights of translation.

* Soon after the discovery of the Leyden jar the necessity of some sufficient indicator of the presence and power of electricity began to be felt, and after some clumsy attempts at an electrometer by Gralath, Ellicott, and others, the Abbé Nollet adopted the simple expedient of suspending two threads, which when electrified would separate by their mutual repulsion. Waitz hung little leaden pellets from the threads for greater steadiness, and Canton, in 1753, improved upon this by substituting two pith balls suspended in contact by fine wires—a contrivance which is used to this day. The electrometer mentioned in the text was of the kind known as the quadrant electrometer, introduced by Henley in 1772.

† "Travels during the years 1787, 1788, and 1789, &c., in the Kingdom of France." Dublin, 1793, Vol. 1, p. 135.

‡ Gerspach's "Histoire Administrative de la Télégraphie Aérienne en France," Paris, 1861, page 7.

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structure on which he was about to spend so much time and labour. Happily, perhaps, he did not live to experience this mortification, for he died January 23, 1805, at the early age of forty-two.

1790.—Réveroni-Saint-Cyr's Telegraph.

This gallant officer is said to have proposed in this year an electric telegraph for announcing the result of the lottery drawings, so as to frustrate the knaveries of certain individuals; but, apparently, details are wanting. (Etenaud's "La Télégraphie Electrique," etc., Montpellier, 1872, Vol. 1, page 27.)

1794.—Reusser's Telegraph.

The next proposal of which we have to speak, and which, in comparison with Lomond's, or Chappe's, was a very clumsy one, is thus described by its author:—*

"I have lately contrived a species of electric letter post, by means of which a letter may be sent in one moment to a great distance. I sit at home before my electric machine, and I dictate to some one, on the other side of the street, an entire letter, which he himself writes down. On an ordinary table is fixed, in an upright position, a square board to which a glass plate is fastened. On this plate are glued little squares of tin-foil, cut after the fashion of luminous panes, and each standing for a letter of the alphabet. From one side of these little squares extend long wires, enclosed in glass tubes, which go, underground, to the place whither the despatch is to be transmitted. The distant ends are there connected to tin-foil strips similar in all respects to the first, and, like them, each marked by a letter of the alphabet; the free ends of all the strips are connected to one return-wire, which goes to the transmitting table. If, now, one touches the outer coating of a Leyden jar with the return-wire, and connects the inner coating with the free end of that piece of tin-foil which corresponds to the letter required to be indicated, sparks will be produced, as well at the near, as at the distant tin-foil, and the correspondent there watching will write down the letter."

Reusser concludes: "Will the execution of this plan, on a large scale, ever take place? That is not the question. It is possible, though it would cost a good deal, but post horses from St. Petersburg to Lisbon are also very expensive. At any rate, whenever the idea is realised, I will claim a recompense."

The editor, Johann Heinrich Voigt, appends to the above communication the suggestion of an alarum, which is usually credited to Reusser himself. Voigt says: "Mr. Reusser ought to have proposed to add to his arrangement a flask of some detonating gas, which one could explode by means of the electric spark, and so attract the attention of the distant correspondent to his tin-foil squares."

In comparing the accounts of Reusser's telegraph usually given with our own, many inaccuracies will be observed. Thus, most writers affirm that each piece of tin-foil was cut into the form of a letter of the alphabet, which, on the passage of the spark, became luminous, as in the French telegraph of 1782, or in that of Salvá, which will presently be described. The German text does not admit of this interpretation, for, if such were the case, it would have been unnecessary to affix letters to the squares of tin-foil. Neither is there any authority for the statement that thirty-six circuits for letters and numerals were proposed, which, according to some writers, were entirely metallic, and, therefore, consisted of seventy-two wires, while others assert that there were only thirty-six wires, and that the earth was employed to complete the circuits. Again, it is always said that Reusser, or rather Voigt, was the first to propose an alarum, whereas we have seen that this was done, twelve years before, by the anonymous correspondent of the *Journal de Paris*, 1782.

1794-5.—Böckmann's, Lullin's, and Cavallo's Telegraphs.

Böckmann, Lullin, and Cavallo, all about this time, proposed various modifications of Reusser's plan, all requiring but one or two wires, and differing only in their methods of combining the sparks and intervals into a code. Böckmann's, which is a mere suggestion, is to be found at page 17 of his "Versuch über Telegraphie und Telegraphen," published at Carlsruhe in 1794;† Lullin's we have not been able to trace further back than Reid's "The Telegraph in America," New York, 1879, p. 69; while Cavallo's is described, at length, in his "Complete Treatise on Electricity," &c. (4th Edition, London, 1795, Vol. III., pp. 285-96), from which we condense the following account:—

"The attempts recently made," says Cavallo, "to convey intelligence from one place to another at a great distance, with the utmost quickness, have induced me to publish the following experiments, which I made some years ago, and of which I should not have taken any further notice, had it not been for the above-mentioned circumstance, which shows that they may possibly be of use for that and other purposes."

The object, for which those experiments were performed, was to fire gun-powder, or other combustible matter, from a great distance, by means of electricity. At first a circuit was made with a very long brass wire, the two ends of which returned to the same place, whilst the middle was at a great distance. At this (middle) point an interruption was made, in which a cartridge of gun-powder, mixed with steel filings, was placed. Then, by applying a charged Leyden phial to the two extremities of the wire (in the usual way) the cartridge was fired.

It proving very troublesome to keep the wires from touching the experiment was tried with one wire only. A brass wire, one-fiftieth of an inch diameter, and two hundred feet long, was laid on the ground, and one end was inserted in the cartridge of gun-powder and steel filings. Another piece of the same wire had, likewise, one end inserted in the cartridge, whilst the other was thrust into the ground. The distant end of the wire was then connected to the inner coating of a charged jar, while the outer coating was touched with a ground wire. That the discharge took place as before was proved by the powder being sometimes fired.

(TO BE CONTINUED.)

* Voigt's *Magazin für das Neueste aus der Physik*, Vol. IX., Part I., page 183.

† Also Zetzsche's "Geschichte der Elektrischen Telegraphie," p. 32.

THE CUBA SUBMARINE TELEGRAPH COMPANY.

The twenty-fourth ordinary general meeting of the shareholders of the above Company was held on Wednesday, the 15th inst., at the offices of the Company, 61, Old Broad-street, Mr. Jonquin de Mancha in the chair.

The Secretary (Mr. James Scott) having read the notice convening the meeting, the report was taken as read.

The Chairman: In introducing to your notice the report and balance-sheet of the last half year I shall have a few words to say to you; and principally of congratulation upon the very favourable and sound position of the Company [applause]. You will see by the accounts that our expenses are very much the same as they were before, and had it not been for about £600 which we spent in repairing the cables, they would have been almost exactly what they amounted to before. The mode in which we are going to distribute, as you will have seen by the report, is to pay the usual 10 per cent. upon the preference shares, and to declare a dividend of 9 per cent., free of income-tax, upon the ordinary shares. I think that will be received with as much congratulation on your side of the table as there has been happiness on our part in being able to lay it before you [applause]. The only thing that I have to say, gentlemen, is that I only hope we shall continue gradually and slowly to increase if possible our dividend, and even if we are to remain as we now are at 9 per cent., we shall all have reason to congratulate ourselves upon the result [applause]. Therefore I will, with your permission, propose "That the report and accounts for the half year ending 30th June, now read, be received and adopted" [applause].

Mr. Alexander F. Low seconded the resolution.

Mr. Griffiths said the shareholders must endorse the observations of the chairman as to the prosperity of the Company. He was rather surprised to find, on looking at the Articles of Association, that they were unable to reduce the number of their directors without an extraordinary general meeting. Having had the misfortune to lose Mr. Hughes as their chairman, their number had been reduced from five to four. There was thus one director less than there ought to be. He mentioned this as a point for the consideration of the directors. As regarded the report, they might consider themselves fortunate that their business had been so good as to justify so large a dividend. He would make a suggestion with respect to the breakage of one of their cables by a ship. If this were to take place near England or within three miles from the coast, there was no doubt that the owner of the ship would be responsible for the result of his negligence, and would have to make compensation for the damage done to the cable by the conduct of the captain and crew of his ship. But they must bear in mind that they were not justified in entering into litigation merely from the possibility of success. He hoped these observations would be taken in good part, as they were made in the interest of the Company. He should rejoice in anything which would tend to raise their dividend. If they had increased dividends, if they wanted from 10 to 11 or even 12 per cent., he thought the good time might be coming when their preference shareholders would consider it wise to throw in their lot with the ordinary shareholders, and share with them the general prosperity of the Company [applause].

Mr. Prust observed that he did not like to see in a Company like this a paltry sum of £106 7s. 7d. carried to the credit side. He did not think it was becoming to their dignity, and it would be much better to wipe out this trifling amount. As regarded the number of directors, he wished to know whether they were on the wrong side legally? If it were necessary to have five he should prefer that number.

The Chairman said, having four directors, they were strictly within the Articles of Association. Of course it would increase the expenditure if they had another director. As regarded the accidents by the vessels injuring their cable, it was but a small matter. Their engineer said it was an accident, and the directors did not think it worth while to enter into a lawsuit to make the captain responsible, for legal proceedings were very expensive, especially in Cuba. As regarded the item for furniture, it was said to be an asset of the Company, and it ought to appear on the accounts.

The resolution was then put and carried unanimously.

The Chairman proposed "That a dividend at the rate of 9 per cent.,

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free of income-tax, on the ordinary shares, and of 10 per cent. on the preference shares, be declared."

Mr. Low seconded the resolution, which was agreed to.

Mr. De Mancha, the retiring director, was next re-elected, Mr. Greenwood, the auditor, being also re-appointed.

A vote of thanks to the chairman and directors closed the proceedings.

PILSEN, JOEL, AND GENERAL ELECTRIC LIGHT COMPANY (LIMITED).

Report of the directors, to be presented to the shareholders at the ordinary annual general meeting to be held on Wednesday, the 22nd inst:—In presenting the accompanying balance-sheet and statement of expenditure and receipts up to the 30th June, 1883, the directors would point out that, although the results of the working of the Company up to the present time are not such as they could have wished, they will be found to be by no means discouraging. It must be borne in mind, in examining this account, that, owing to the time occupied in fitting up the factory, the whole cost of thirteen months' expenses has been charged against the results of little more than six months' work, and that a large portion of the operations of the factory has been devoted to experiments with a view to improvements and economy in the construction of the several forms of the Company's apparatus. The directors, therefore, do not consider that these results furnish any guide as to the future operations of the Company, or present any reasonable discouragement to the shareholders; more particularly as the stock on hand, which is valued at cost price, may be expected to produce within a short period of improving trade in electric apparatus—of which the signs are already visible—sufficient profits to wipe off a large portion of the debit balance. Before the directors had overcome the delays and difficulties attendant upon the installation of their works, and the manufacture of a supply of lamps and dynamos, the winter season had passed, the demand for electric lighting had almost ceased; and, consequently, after little more than four months of active production, the directors deemed it prudent to husband their resources, and to reduce the manufacturing expenditure to a minimum, pending a revival of the trade. The action of Parliament has greatly contributed to check the demand for electric lighting, to suspend the action of all municipal bodies, and to encourage the public generally to look for more advantageous terms by waiting. During last year the discussion and passing of the Electric Lighting Act, and during this year the discussion and successive delays in the several stages of the provisional orders, have in fact nearly suspended the operation of all the electric lighting companies. The passage, however, by Parliament of a large number of provisional orders, which is now almost assured, will doubtless give an important impetus to electric lighting, in which this Company may look forward to having a full share. Of the three provisional orders for areas in London for which the directors originally applied, one, viz., that for a portion of Holborn and New Oxford-street, passed the House of Commons without opposition, and will, beyond doubt, receive the Royal assent before the end of the Session. The local authorities controlling the other two areas (one in connection with the Company's factories in the parish of St. Pancras, and the other in the city of London) having decided to apply for provisional orders for themselves, and having expressed their willingness to arrange with this Company for carrying out the work in a portion at least of the contemplated areas, the directors decided not to proceed with their applications. The directors are arranging with the Corporation of an important provincial city to light its principal streets. They are in negotiation for several important public contracts, and have orders in immediate prospect for arc and incandescent lamps, which will, they anticipate, speedily bring their factories into activity. Arrangements have been made with an influential company for the introduction of this Company's lamps into the several Australian Colonies, and the directors are at present in negotiation for the sale of concessions in that part of the world. They continue to view the colonial patents as an important asset of the Company. The directors have employed the slack season of manufacture in improving the old forms, and in working out new forms of their manufactures. Their present forms of Pilsen arc lamps and dynamo machines exhibit much greater efficiency than the original models of foreign make. They have also been engaged, and succeeded in completing a single coil arc lamp, which can be sold at a reduced price, and will supply a desideratum in factories and places where their cheapness will be a recommendation. They have also succeeded, after patient and prolonged trials and experiments, in perfecting the Gatehouse incandescent lamp, which, as the prospectus announced, was not complete when the Company took over the patents, and they believe that this lamp is now second to none in efficiency. A series of tests and trials made between it and the other principal forms of incandescent lamps has shown the Gatehouse to be the most economically worked of all, and the directors count upon its proving a valuable source of profit to the Company. The dynamos manufactured by the Company have also been adapted to run incandescent lamps. The shareholders are doubtless generally aware of the two attempts which have lately been made to injure the credit of the Company and to force it into liquidation. The circular of Messrs. J. G. Osborne and Co. collapsed with the repudiation of its author by two out of the four shareholders of whose names he had made use; and a petition addressed to the High Court of Justice to wind up the Company, which was presented by three shareholders owning 150 shares (one of whom was named in Messrs. Osborne's circular), and which was opposed by the holders of 20,105 shares, was dismissed with costs, no attempt being made by the petitioners to justify their action. The directors refrain from commenting upon these proceedings, but they congratulate the shareholders upon the result. In order to meet the requirements of the business, and to complete the partly manufactured stock, a call of 10s. per share has now become necessary, notice of which is herewith sent. The directors do not anticipate having to make another call, except for the purpose of carrying out provisional orders, or other works requiring a heavy outlay of capital, and the shareholders may be assured that the directors, who hold a very large stake in the Company, have no desire or intention of carrying on the business except with a reasonable prospect of its becoming profitable. They have confidence in the extensive adoption of electric lighting in an early future; they have faith in the doctrine of the survival of the fittest; and they believe that this Company contains the surest elements of future success in the possession of the best arc lamp in the market, and of semi-incandescent and incandescent lamps equal to any. The directors have conducted the business of the Company and maintained its character during a period of great depression in electric lighting, and, although the results of the first year's operations have been as disappointing to themselves as to the shareholders, they believe that they have laid the foundation of a profitable business, and they look with confidence to the shareholders for their support and encouragement in their efforts to establish and carry it on to a successful issue. The auditors to the Company, Messrs. Broom, Hays, and Akers retire, but, being eligible, offer themselves for re-election.

COMPANIES' SHARE LIST.

TELEGRAPHS.

Companies.	Closing Prices Aug. 15.		Business Done Week Ending Aug. 15. Highest.	Lowest.
Anglo American	48,	48½	48	47¾
Do. Preferred	79½,	79¾	80¼	79
Do. Deferred	17¼,	17¾	17¾	17½
Brazil Submarine	11¾,	12	11 15-16	11 13-16
Cuba	11¼,	11½	11⅝	11¼
Do. Preference	17¾,	18¼	18½	—
Direct Spanish	5,	5½	—	—
Do. Preference	15¾,	16¼	15⅞	—
Direct United States Cable	12½,	12¾	12¾	12 7-16
Eastern Telegraph	10 11-16,	10 13-16	10 15-16	10 9-16
Do. 6 per Cent. Preference	12⅝,	12⅞	12 13-16	12 11-16
Do. 5 per Cent. Debentures, 1899	103,	107	107	—
Eastern Extension	11⅜,	11⅝	11⅝	11⅜
German Union	9¾,	10¼	10½	—
Globe Telegraph and Trust Company	7¼,	7⅜ x d.	7⅝	7⅜
Do. Preference	12⅝,	12⅞ x d.	12 15-16	12¾
Great Northern	12⅝,	12⅞	12 13-16	12 11-16 x d
Indo-European	31½,	32½	—	—
Mediterranean Extension	1½,	2	1¾	1½
Do. Preference	2,	4	—	—
Reuter's	9½,	10	—	—
Submarine	230,	240 x d.	243	—
West India and Panama	¾,	1	1	⅞
Do. 1st Preference	6½,	6¾	6⅝	6½
Western Brazilian	5¾,	6¼	6⅛	5⅞
West. Union 7 per Cent. 1st Mortgage	122,	124	—	—
Do. 6 per Cent. Sterling Bonds	103,	105	—	—

TELEPHONES.

Consol. Telephone and Maintenance	7-16,	9-16	9-16	—
Oriental	5-16,	7-16	⅜	5-16
United Telephone	8⅛,	8⅜	8⅝	8¼

ELECTRIC LIGHT.

Anglo-American Brush Lgt. (£7 paid).	2⅛,	2⅜	3 9-16	2⅜
Do. (fully paid)	5½,	6½	7	6
Hammond Light	¾,	1	1¾	13-16
Swan	1 15-16,	2 1-16	2	1 15-16
Maxim-Weston	1-16	3-16	—	—

MISCELLANEOUS.

Telegraph Construction	33⅝,	33⅞	34	33½
India Rubber, Gutta Percha, and Telegraph Works	28¾,	39¼	29⅝	29¼

TRAFFIC RECEIPTS FOR JULY, 1883.

Companies.	July, 1883.	July, 1882.	Incrse.	Decrs.
Anglo-American Telegraph Company	—	—	—	—
Brazilian Submarine Company	—	—	—	—
Cuba Submarine Company	2,700	2,921	—	221
Direct Spanish Telegraph Company	—	—	—	—
Direct United States Cable Company	—	—	—	—
Eastern Telegraph Company	—	—	—	—
Eastern Extension Telegraph Company	36,177	30,070	6,107	—
Great Northern Telegraph Company	22,400	—	—	—
Submarine Telegraph Company	—	—	—	—
West Coast of America Telegraph Company	—	—	—	—
Western and Brazilian Telegraph Company	—	—	—	—

Numbers of "The Electrician" out of Print.—The following numbers of *The Electrician* are out of print, and cannot be supplied at the office, viz.:—Vol. 1, Nos. 3, 9, 19; Vol. 7, Nos. 8, 10, 12 to 18, 20, 21, 24 to 26; Vol. 8, 1, 3, 6 to 12, 15 to 26; Vol. 9, Nos. 2, 4, 24, 25; Vol. 10, No. 13.

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NOTES.

Postal Telegraph Appointment.—Mr. B. Tansley, telegraphist of London, has been appointed Postmaster of Beverley.

The Patents Bill.—The Patents for Inventions Bill was read a third time in the House of Lords on Tuesday last, and passed.

Exhibition at Louisville.—The Southern Exhibition Building at Louisville, U.S., is, we read, to be lighted by 4,600 Edison lamps.

Brazilian Submarine Telegraph Company.—The traffic receipts of this company for the week ended the 10th inst. amounted to £3,061.

Electric Lighting in San Francisco.—The Oregon Steamship Company are going to light their wharf at San Francisco by means of the Edison system.

New Company.—The Exchange Telegraph Company has been formed in New York. It is to run lines from New York to San Francisco, at least so the papers say.

Provisional Orders.—In the House of Lords on Monday last, the Electric Lighting Provisional Orders (Nos. 1, 5, 6, 7, and 8) Bills were read a third time and passed.

West India and Panama Telegraph Company.—The estimated receipts of this company for the half month ended the 15th inst. are £1,958, as compared with £2,358 in the corresponding period.

The Foochow-Shanghai Cable Repaired.—The Eastern Telegraph Company notifies the restoration of the Foochow-Shanghai cable. Telegrams are now arriving from Foochow and Shanghai by this company's route with their customary regularity.

Domestic Electric Lighting.—Messrs. R. E. Crompton and Co. are about to light the house of Mr. W. S. Gilbert, well known as the composer of the music of *Iolanthe*, &c., with Swan incandescent lamps. Mr. Gilbert will design his own fittings.

Western and Brazilian Telegraph Company.—The traffic receipts of this company for the week ending 10th August, were £1,936, after deducting the "fifth" of the gross receipts payable to the London Platino-Brazilian Telegraph Company.

The Late Mr. Spottiswoode.—The *employés* of the late Mr. William Spottiswoode, President of the Royal Society, have resolved to erect a monument to his memory, which will be placed in front of Her Majesty's printing office. Mr. Belt has been commissioned to execute the work.

Post Office Telegraphs.—It is announced that an open competition for admission to the Post Office (Male) School of Telegraphy (age 14—18) will be held in London on Sept. 12. Particulars and the necessary form of application can be had of the Secretary, Civil Service Commission, London, S.W.

Appointment.—Mr. J. D. Miller, manager of the National Telephone Company's Exchange at Greenock, has been appointed manager of that company's exchange in Aberdeen. Before leaving Greenock Mr. Miller was presented with a handsome silver inkstand, as a mark of the esteem in which he was held in the town.

Cardiff.—It is reported that a local telephone company is to be organised at Cardiff. As, however, the Post Office already have an exchange here, and the company must obtain the Postmaster-General's consent before they can establish an exchange, some negotiating will probably have to take place before the company gets to work.

Scarcely Likely.—A provincial paper informs its readers that "Mr. Edison has decided to give up inventing for a a year, in order to push his electric light business." We should sooner expect to see the sun stand still for 365 days than Edison give up inventing for the like period. We wonder where the *Cork Daily Herald* got its information from.

The Lighting of the "House."—Nothing has yet been settled, says the *Daily News*, with respect to the renewal of the experiment of lighting portions of the House of Commons with electricity. A scheme has been submitted for extending the experiment to portions of the House of Lords, and to lighting "the black hole" at the back of the Press Gallery, but the proposals have not been accepted.

Worcester.—The Town Council of Worcester have resolved to apply for a provisional order to supply electricity for lighting purposes, &c. The old cathedral city is very favourably situated for the utilisation of the water power now running to waste in the Severn. Should the council follow the matter up to its conclusion we shall expect to hear that the Severn has been largely drawn upon for the necessary motive power.

Sermons by Telephone.—Bradford (Yorks.) is following the example of Greenock, Edinburgh, and other towns. We hear that the National Telephone Company's exchange in that town is connected with the Chapel Lane Unitarian Chapel, and that many subscribers now listen to the utterances of their pastor through the medium of the telephone. We are afraid that the telephone may fall into some discredit amongst preachers, if congregations elect to be sermonised at home. We believe, however, that the majority of those who use this novel means of being present in spirit, but absent in body, are invalids, and to these the telephone must be an unexpected boon.

Spectra of Carbon Compounds.—In a paper in the *Ann. Phys. u. Chemie*, Vol. 17, pp. 427, &c., Herr K. Wesendonck describes the spectra produced by electrical discharges through the rarefied vapours of compounds of carbon and hydrogen, or of these combined with nitrogen and oxygen. Herr Wesendonck considers he has proved that the spark spectrum of bands described by Mr. Swan is due to carbon itself separated from its compounds in a sufficient quantity and at a sufficiently high temperature, for which it is necessary that a comparatively large quantity of electricity shall pass each unit of section in the unit of time. On the other hand, the channelled spectrum (called by Watts the second) must be ascribed to oxide of carbon.

The Berlin Opera House.—This opera house was recently re-opened, after having been somewhat improved as to its internal arrangements. Amongst other things the *foyer* has been lighted by means of electric lights, the result of which has been to considerably reduce its temperature as compared with that experienced before the introduction of the electric light, and also to make it a comparative icehouse as contrasted with the auditorium of the Opera House. The correspondent of a daily paper, describing the opening night, says:—"I saw not a few ladies hastily wrap themselves up in cloaks, and some incontinently retire from the dangerous through grateful coolness of the *foyer*." The next best thing for the authorities to do is to light the whole building by the new system.

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The Strike of American Telegraphists.—The following items of news with regard to this strike have been received since our last issue. The *Daily News* New York correspondent, telegraphing on Friday, Aug. 17, said:—"The telegraphers are returning by dozens. The strike is over. Those returning sign a pledge to renounce the Brotherhood and not to join any organisation the object of which is to dictate to the company respecting the rate of wages." On the following day a Reuter telegram stated that:—"The leaders of the telegraph strike have to-day issued an official announcement to the effect that the movement has proved a failure." A *Times* telegram, dated Philadelphia, Aug. 20, gave further particulars as follow:—"The strike of the telegraphists ended in the Eastern States on Friday night, when the master workman Campbell issued a circular confessing the failure of the movement, and permitting the strikers to resume work. The Western operators held out until to-day, when they also yielded. The strikers will be taken back so far as is necessary to fill the places still vacant."

The Adoption of a Common Time.—We understand that Her Majesty's Government having through the Foreign Office been invited to appoint delegates to the International Geodetic Congress to be held at Rome in October next, at which the adoption of an international common meridian and common time for railway and telegraph purposes is to be discussed, the Lords of the Committee of Council on Education appointed a committee to report on the subject. The committee consisted of the Astronomer-Royal, General Cooke, C.B., R.E. (late Director-General of the Ordnance Survey); General Strachey, C.S.I., R.E. (Member of the India Council); and Colonel Donnelly, R.E. (Secretary of the Science and Art Department). In consequence of their report the Treasury have consented to provide the travelling and personal expenses of two delegates. We are glad to say that the Science and Art Department, in concert with the Foreign Office, have appointed the Astronomer-Royal and Colonel A. R. Clarke, C.B., R.E., F.R.S., to represent this country, and that they have consented to act.—*Nature*.

Steam Power at the Fisheries Exhibition.—On Wednesday, at the invitation of Mr. Paxman, of the firm of Davey, Paxman, and Co., Colchester, a number of gentlemen met to inspect the steam power supplied by the firm at the Fisheries Exhibition. After an excellent dinner in the Royal Pavilion, at which Mr. Birkbeck, M.P., presided, the guests inspected the engines. We shall not here enter into any details of the work carried out by Mr. Paxman's firm, inasmuch as that will, we trust, be fully given in the articles which have been commenced in our pages, and which we intend to contain all information of value to our readers. Mr. Birkbeck, in proposing the health of the host, Mr. Paxman, complimented him very highly upon the energy of the firm in coming to the aid of the Commissioners, and upon the great excellence of the engines supplied. Mr. Paxman, in replying, stated that the engines had been designed and completely built in the short space of ten weeks, and this during a busy time. We noticed that one of the largest engines has been purchased by the Government for the South Kensington Museum.

Utilising Wave Power.—Mr. C. W. Harding, of King's Lynn, calls our attention to a scheme of his for utilising the power of the waves to drive dynamos, and so generate electricity for use on shore. Briefly stated, his plan is this: Off the coast he anchors a vessel specially adapted to withstand rough weather. In the centre of the vessel is a large main driving wheel, which is rotated by means of a chain passing over it, one end being permanently attached to a heavy weight at the bottom of the sea, and the other to a small weight, whose function is simply to keep the chain from riding off the wheel. The motion of the waves causing the ship to rise or fall, rotates this wheel, which being mounted on a main shaft connected with air compressing machinery and reservoirs stores up compressed air, which the inventor proposes to utilise by means of an air-engine for driving dynamos. The current can be delivered on shore by means of a cable, and used at once or stored in secondary batteries. A vessel similar to the class Mr. Harding proposes to adopt is now being used for a water bailiff's residence off the Norfolk coast, and our correspondent informs us that he will be glad to show her to any one interested in the matter.

Gilchrist Engineering Scholarships.—The Gilchrist Engineering Entrance Scholarship at University College, London, will be open to competition at the end of September. The conditions of examination are this year somewhat altered, in a direction which places the scholarship better within the reach of those for whose benefit it was founded. The detailed regulations can be obtained on application to the secretary of University College; the following is a summary of them. Candidates must be under nineteen years of age, and must send in notice to compete by the 23rd of September. The subjects of examination are:—1. Elementary Mathematics, and 2. Any two or more of the following five subjects: Mechanics, Mechanical Drawing, Essay on one of three given subjects connected with mechanics or engineering, French or German. The use of tools, either carpenters' tools, or the lathe (wood or metal), or the file. The scholarship is of the value of £35 per annum, and is tenable for two years. There is also at University College a Senior Engineering Scholarship, awarded at the close of the session, of the value of £80. The regulations affecting this scholarship, as well as those of the Andrews Entrance Prizes, &c., can be obtained on application to the secretary.

Vienna Electrical Exhibition.—This exhibition was officially opened last week. Though far from complete, we shall hope to give our readers some particulars concerning what is to be seen at Vienna in an early issue. In the meantime we may quote the following, as being the latest information up to the time of our going to press. On Wednesday night the *Daily News* correspondent telegraphed, "To-morrow night the Electrical Exhibition will be lighted up for the first time. The Emperor will be present. A telephonic service will also be opened. On Friday the theatrical performances commence, the rehearsals for which were held yesterday in presence of King Milan. On Saturday Sir William Siemens will deliver a lecture. King Milan has bought an electrical rifle with 1,000 cartridges. The electrical railway is almost complete. A very fine lighthouse has been put up in the French Department. Sir William Siemens has addressed a letter to the Electrical Society in London, informing it that the importance of the Vienna Exhibition has been underrated in England, and that exhibits should be sent even now, as they might be of great use. Last night the great light on the lantern of the Rotunda was visible for many miles around. The light penetrates through the glass roof, producing a magic effect outside, which attracts crowds in front of the entrance gate. The committee still complains of the lack of steam power."

Lightning Descending a Coal Mine.—A Newcastle paper reports that at 4 p.m. on Friday in last week at Dinnington Colliery, the property of Messrs. John Bowes and Partners, a flash of lightning seemed to strike the west winding rope of the west shaft in its elevated position upon

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the pulley. One current passed down into the winding engine house, where it was seen to flash up and down the feed pump, below the level of the floor, and quite illuminated the place at the time; another current passed down the rope to the bottom of the shaft, a depth of 35 fathoms, striking the cage, which fortunately was standing upon the bottom at the time, and exploding. The onsetter describes it as like a ball of fire falling upon the iron flat sheets at the bottom. He had his hand upon the cage, and received a smart electric shock, and was nearly blinded by the flash for the moment, but fortunately received no personal injury. The shaft is fitted up with round wire-rope guides for two cages. These guides are suspended from the top of the pulley frames or head gearing, and secured at the bottom by heavily-weighted levers. After careful examination of the frames, pulleys, ropes, shaft, &c., no injury could be detected. The colliery was struck during a thunderstorm. In this connection it is interesting to note that the report of the lightning rod conference draws attention to the liability of collieries to be struck in this very way, and recommends that the head-gear of all shafts should be protected by proper lightning conductors.

Telegraphs in Europe.—The following table gives according to statistics published by the European Telegraph Bureau, the numbers and length of electric telegraph lines in the various countries of Europe, with the number of inhabitants to each office in the principal countries:—

Country.	Number of Lines.	Total Length. Miles.	Inhabitants to each Office.
Germany	10,308	161,954	4,388
France	5,885	140,436	6,342
Russia	2,731	138,902	27,091
Great Britain	5,600	122,856	6,294
Austria	2,604	57,522	8,504
Italy	2,470	56,235	10,850
Hungary	1,069	34,083	—
Spain	385	25,315	43,358
Sweden	788	18,565	5,794
Belgium	827	17,350	—
Switzerland	1,139	10,040	—
Norway	260	9,693	7,411
Holland	418	8,782	—
Portugal	202	6,644	—
Roumania	206	5,382	—
Denmark	387	5,250	—
Greece	100	2,867	—
Servia	60	2,569	—
Bulgaria	37	2,113	—
Bosnia	69	1,976	—
Luxemberg	64	395	—

The Hammond Electric Light Company.—This company have issued a circular calling up £2 10s. per share. The following are the directors' reasons for this step, as expressed in this circular. They state that "On the threshold of another lighting season, the directors are confronted with so many applications for installations on hire that they see prospects of employing very profitably the share capital which hitherto they have refrained from calling up. In order to have a good district completely under its own control the company have promoted and carried through Parliament a provisional order, drawn in favourable terms and on a sound commercial basis, for supplying Hampstead with electric light, under the provisions of the Electric Lighting Act, 1882. Part of the money now called up will probably be used in carrying out the requirements of this provisional order. Mr. Robert Hammond has just returned from a visit to the United States, and without going more into detail at the present moment as to the object of Mr. Hammond's journey, it may be stated that it is not improbable that some portion of the capital now called up may be judiciously and profitably employed, not in buying, but in working an American patent, which will, it is believed, have a marked influence in cheapening the supply of electric light. In conclusion, the directors are anxious to emphasise the fact that the call of the remainder of the share capital of the company is for the purpose of providing a strong reserve to cope with new business of a sound and highly remunerative nature."

The Electrical Transmission of Power.—It appears that M. Deprez has with his well-known energy been making still further experiments on the transmission of power. We take the following account of these experiments from the *Daily News* of Tuesday last, that paper having received the information from its Paris correspondent. We shall probably have some more scientific details of this matter before long; in the meantime we advise our readers not to forget that chloride of sodium is often necessary when digesting newspaper reports of scientific experiments. Here is the account:—"M. Marcel Deprez made the other day a most successful application of his theories on the transportation of force at Grenoble. This city, being in a mountainous country, is surrounded by numerous streams and torrents, developing an amount of force which, if utilised, might be a source of immense wealth. The municipality of Grenoble invited M. Marcel Deprez to repeat the experiments which he had performed with success at Munich and at the Gare du Nord at Paris. The force was supplied by the torrent of the Romanche (14 kilometers from Grenoble), and thence conveyed along a copper wire of two millimetres in diameter. The mechanical yield was about 60 per cent., and the utilised force seven-horse power. A part of this pumped some water employed to produce an artificial cascade. The remainder M. Deprez divided between all the machines of a small workshop, and lit besides 300 Edison lamps. On the occasion of the above experiments a banquet was given by the municipality in honour of M. Deprez."

The Telephone at Balmoral.—The work of erecting telephone lines at Balmoral for the Queen's use has successfully been accomplished. The wires radiate from the Castle at Balmoral to the Albert Memorial Hall at Ballater; to Abergeldie Castle (the Highland residence of His Royal Highness the Prince of Wales); and to the house of Dr. Profeit (Her Majesty's Commissioner) at Craig Gowan. Arrangements have been made for the whole of these places to have telephonic intercommunication; and, further, as Ballater is the nearest telegraph station to Balmoral, messages for Windsor, Osborne, and other places will be telephoned to the Albert Memorial Hall, and thence handed to the Ballater Post Office for transmission by telegraph; and, on the other hand, telegrams received at Ballater for Balmoral, Abergeldie, or Dr. Profeit, will be telephoned to their destination after being handed over by the telegraph officials to the telephone operator for that purpose. The operations have been carried out by Messrs. Tasker, Sons, and Co., electrical engineers, Sheffield, who, in order to complete the communications before the arrival of Her Majesty on the 25th inst., have employed a large staff of workmen for some weeks past, under the personal direction of Mr. Johnson, their engineer and electrician. Conversation over the wires can now be carried on with ease and distinctness, and special messages notifying this fact have been despatched by the new system from Balmoral to Her Majesty at Osborne. The instruments adopted are Johnson's transmitters (authorised to be used by the Attorney-General) and Bell's telephones.

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ELECTRICITY IN CAMPOS (BRAZIL.)—"The electric machinery at Campos consists of two Brush dynamos for 39 2,000 candle, nominal, arc lights, and a Weston dynamo for 50 Maxim incandescent lights, driven by a steam engine of 50 horse-power, nominal. The experiment on June 24th was not a success, and on the 27th June the whole of the lights went out twice, the second time for nearly an hour, leaving the streets in total darkness, and during the remainder of the night the illumination was very fluctuating, several lights being out. On the night of the 3rd July the same eclipse occurred, the streets being left in utter darkness, the Maxim lights in the three shops that have tried them also going out. Even after lighting up again there were continual failures among the arc lamps, and the general illumination was most uncertain and very inefficient. The municipality has not yet accepted the lighting, and very fortunately for the undertakers they have not, we hear, yet paid for the Brush machinery, into whose ordering they were seduced by the glowing representations of a resident American machinist and of a peripatetic agent of the United States Brush Company. The talented editor of the *Revista da Engenharia*, organ of the Rio Club da Engenharia, which was represented at the inauguration by Dr. Aarao Leal de Carvalho Reis, Engineer Joseph Lynch and Commendador Malvino Reis, gives as his opinion that the municipality of Campos would have done better to have adopted for the street lighting, instead of the Brush arc system, any one of the present systems of incandescent electric lighting, preferably the Edison." Thus we read in the *Anglo-Brazilian Times*. This report, if correct, savours of bad workmanship, and installations so carried out are detrimental to the progress of the electric light.

EARTHQUAKES.—Earthquakes have been reported during the week as having taken place in Switzerland. A Geneva telegram, dated August 21, says:—"A shock of earthquake sufficiently strong to move beds and displace crockery occurred last Thursday at Schuols, Pontresina, and Tarasp, in the Engadine. The shock was preceded by a violent storm and heralded by a peal of subterranean thunder." According to *The Times* the island of Ometepee, in the lake of Nicaragua, has just been utterly devastated by a volcanic outbreak, causing an overflow of several lava streams which filled up several valleys, and engulfed in its fiery current farmsteads, cattle, and all the cultivated fields. The eruption began on June 19, when a new crater opened. A continuous earth-tremor resulted in an overflow of lava directed towards Las Pilas. Two days later several other hills opened, pouring out lava in every direction, and the terrified inhabitants fled. Boats were sent from the neighbouring towns to save them. Unfortunately some persons took refuge on a hill, which was soon completely insulated by the surrounding lava. It was impossible to devise any way of saving them, and they perished miserably. The whole island is described to be at present a heaving mass of molten lava, quite uninhabitable. Professor Palmieri has issued a report on the Ischia earthquake, his conclusions being that it was, "A small or moderate earthquake causing immense disaster. The continuous wearing away of the soil by the hot subterraneous springs is sufficient to explain the immense catastrophe, which has been enhanced by the very bad construction of the houses. Some damaged by the earthquake of 1881 had remained without repairs. The disaster of 28th July will be recorded more on account of the enormous loss of life and property than of its seismographic importance."

EFFECT OF LIGHTNING ON TREES.—The Geneva correspondent of *The Times* writes:—"The frequency of thunder-storms in Switzerland this summer (we have on an average two a week) has afforded Professor Colladon, of Geneva, a great authority on electricity and meteorology, ample opportunity of continuing his observations on the effect of lightning on trees and vegetation generally. He has ascertained that when lightning strikes a tree it leaves very few marks of its passage on the upper part and middle of the trunk, a peculiarity which he ascribes to the fact of those parts being more impregnated with sugar (a good conductor) than the lower part. As the electric fluid descends to the neighbourhood of the heavier branches, where there is less saccharine matter, it tears open the bark and in many instances shivers the tree. It is no uncommon thing to find the lower part of a tree literally cut by the lightning, while the upper portion and the higher branches seem to have suffered hardly at all. Oaks, however, would appear to present an exception to this rule, for they are often found with tops quite blasted and the passage of the lightning lower down marked by a gouge-like furrow. These furrows sometimes go completely round the tree like a screw, the reason of which, says Professor Colladon, is that the lightning follows the cells of which the bark is composed lengthwise, and in certain sorts of wood these cells are disposed spirally. A curious effect of lightning on vines is that it invariably strikes a great many vine stocks at the same time over a space, for the most part circular, from 8 metres to 25 metres in diameter, and containing, therefore, several hundred vines. The plants most affected are those in the centre of the circle, and the number of burnt and yellowed leaves diminish in proportion to their distance from that point. In July two vineyards in this canton were struck by lightning, and the first idea of their proprietors, on seeing their shrivelled vines, was that a still more dreaded foe, phylloxera, had been at work, but when the professor was called in, he speedily enlightened them as to the true cause of the mischief, and, in proof of his diagnosis, pointed out that the ground in the centre of the circle was strewn with torn leaves and freshly-broken twigs."

ELECTRIC LIGHTING ON THE "MALABAR."—We briefly mentioned in our last issue that this troopship had been lighted throughout by the Edison Company. The generating plant consists of two Edison L or 150-light dynamos, driven by two direct-acting Brotherhood engines. The various tests which have been made by the Admiralty officials have proved eminently satisfactory, and the manner in which the details of the work have been carried out by the Edison company has been the subject of favourable comment on the part of the officials, the very effective lighting of the saloon being especially commended. The lamps are distributed as follows:—On the forward part of the upper deck there are twenty-five half lights and one full light; the latter is placed in the captain's cabin on the lower bridge, whilst the half lights are scattered about in the forecastle (four), in the several latrines, horse stalls, dispensary, chart house, wheel house, &c. On the after part of the upper deck there are eleven half lights and one full light, these lighting up the saloon staircase, chronometer room, nursery, ladies' cabin, after wheel house, &c. The fore part of the main troop deck is lighted by six full lights and seven half lights, and the after part of the same deck by six full lights. These afford light to the women's quarters and wash place, the hospitals, engineers' sleeping cabin, and so on. The lower troop deck has five full lights and four half lights, the lower saloon and steerage six half lights, the forepart of the upper deck and waists, two full lights, and twenty-eight half lights, and the upper saloon fifty-four full lights. These latter are distributed as follows:—Knife room one, saloon pantry two, saloon bar one, saloon pilaster

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twenty-five, saloon pendants twenty-two, lobby two, ship's office one. The main troop deck forward has two full lights and eighty-four half lights, whilst the upper part has twenty-eight half lights. In the lower troop deck (forward) there are thirty-four half lights, whilst the steerage and lower saloon have twenty-four ditto. The engine room is lighted by twelve full lights, the boiler room has sixteen ditto, the shaft alley seven ditto, and the condenser room four half lights. There are two half lights which act as pilots in the dynamo room, and sixteen are employed at the starboard yard arm, and a similar number at the port yard arm. This brings the total number of lights on the ship up to 112 full, and 295 half.

Bourseul's Claims to the Invention of the Telephone.—A correspondent sends us the following interesting communication:—"After the able manner in which Professor S. P. Thompson has put forward the claims of Reis as the first and true inventor of the telephone, as opposed to those of Bell, it is rather surprising to suddenly come across a publication to the effect that the labours of both these men have been anticipated by one Charles Bourseul, in 1854. The publication in question is a lecture delivered by Captain Holthof, in April, 1881, to the Electrical Society of Frankfort, and will be found on page 48 of that society's *Journal*, which, for some reason unknown, has only just appeared. The following passage, quoted from the lecture, will be read with interest: 'If we agree to call the true inventor that man who is the first to conceive clearly a new idea, and who tells us how this idea can be carried out in practice, then the telephone was invented in 1854 by Charles Bourseul, a Frenchman, and about that time a soldier in the African army.' We learn further from the same source that the invention had been communicated in 1854 to the French Academy, and that more or less detailed descriptions of it went the round of the German papers of that period. Notable in this regard is one article which appeared on the 28th September, 1854, in the *Didaskalia*, a supplementary paper to the *Frankfurter Journal*, which sets forth the very gist of the invention so clearly, that, in spite of its ancient date, a short abstract from this paper may be interesting to our readers. 'An electric current passing through a wire transforms a piece of soft iron into a magnet. If the current ceases the magnetism also ceases. This electro-magnet can be made to alternately attract and release a movable plate, which in its to-and-fro movements produces the conventional telegraphic signals. Now, it is also known that all sounds which reach our ear are produced by vibrations in the air, and that the infinite variety of sounds depends solely on the speed and magnitude of these sound-waves. If, now, a metal disc could be invented which would be flexible enough to reproduce all the sound-waves transmitted to it by the air, and if that disc could be connected to an electric circuit—such a way that in conformity with the vibration of the air it would start and interrupt the current —then it would also be possible to cause a similarly-constructed metal disc, in electrical connection with the first, to repeat all the movements of it, and the effect would be the same as if one had spoken directly against this second disc —that is to say, the ear would be affected in the same manner as if it heard the speech directly through the first metal diaphragm.' Captain Holthof considers it very astonishing that Reis did not know of Bourseul's invention, but infers this to be the case, as otherwise he would have introduced at once the second diaphragm. As regards Bell, the lecturer thinks it 'downright incredible' that Bourseul's labours should not have been known to him. In conclusion, Holthof suggests that Bourseul should be recognised as the father of the telephone." We may add that the claims of Bourseul in this direction have had a most notable advocate in M. le Comte du Moncel, the well-known and prolific writer on electrical subjects.

The Board of Trade and Electric Licenses.—The following is the letter from Mr. Calcraft, of the Board of Trade, referred to in our leading columns, and which appeared in all the daily papers on Saturday last:—"Sir: The Board of Trade have had under consideration the applications for licenses which have been made to them under the Electric Lighting Act. Some of these applications are made by electric lighting companies, and extend over large areas, involving a large expenditure of time and money. According to the terms of the Electric Lighting Act such licenses can only be granted for seven years, and at the end of that time the undertakers and all the capital they may have expended are subject to the decision of the local authority and the Board of Trade as to whether the license should be renewed, and if so on what terms and conditions. It must be some time from the date of the license, probably two or three years, before such an undertaking can be brought into full operation, and there would then remain not more than four or five years during which the undertakers could expect to reap the fruits of their enterprise. During this period, moreover, they would be exposed to severe competition with gas. It is difficult to believe that under such circumstances prudent and capable investors will be found able and willing to provide the capital necessary for so large and so hazardous an undertaking; and that which is unsafe and imprudent for investors can seldom be for the ultimate good of the public. But this is not all. The grant of a license when approved by local authority and adopted by the Board of Trade is final, and there is not, as in the case of a provisional order, any means of preventing or modifying it by an appeal to Parliament. If, therefore, as has lately been the case in more than one instance, consumers should be dissatisfied with the action of the local authority and of the Board of Trade they will in case of a license have no remedy. Under these circumstances the Board of Trade have come to the conclusion that they will grant no licenses to electric lighting companies for wide areas, such as the whole of a provincial town, or of a London parish. This does not apply to smaller areas containing, for instance, a limited number of streets, squares, or public buildings, which a company may well be willing to light by way of experiment or otherwise. Nor does it apply to cases in which local authorities themselves are the applicants for the license. I am to add that the Board of Trade, whilst adopting the above conclusion, and making it known for the convenience of applicants, do not propose to proceed with any of the licenses now before them until October." This letter was followed by one from Mr. John Jones, chairman of the Electric Lighting Committee of the Strand Board of Works, addressed to *The Times*. Mr. Jones asks why the Board of Trade did not publish their intention not to grant licenses, except as mentioned in Mr. Calcraft's letter, at an earlier date, and thereby save the Jablochkoff Company, amongst others, the expenses attending their application for a license for the Strand District, and for its support before the Houses of Lords and Commons. Mr. Jones thinks that the matter may safely be left in the hands of the local authorities and the investors. Mr. Francis R. Reeves, secretary to the Jablochkoff Company, also wrote to the *Daily News*, dealing with the question in much the same terms as Mr. Jones, but at greater length.

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CURRENT ENERGY.—VII.

BY OLIVER HEAVISIDE.

(CONTINUED FROM PAGE 296.)

In electrostatics and electro-magnetism there are remarkable minimum properties connected with the energy of distributions of magnetic and electric force. We considered this matter in Art. IV. with respect to magnetic force, either arising from closed currents, and therefore consisting of closed tubes, in which case the value of the summation ΣB_1^2, where B_1 is the force, is the least possible, the force being supposed to vary in any manner consistent with the same currents; whilst if arising from magnetism, say now B_2, the value of ΣB_2^2 is the least possible, the force varying in any manner consistent with the same distribution of magnetism, the ultimate reason being that $\Sigma \overline{B_1 B_2}$ through all space is zero, when B_1 has no convergence, and B_2 no curl.

In connection with Ohm's and Joule's laws there is a similar property, which, in its present application, is particularly useful and instructive, for, owing to the general better acquaintance with current than with magnetic force, and the certainty that we are really dealing with energy and its distribution, or its rate of transformation from one form to another, practical interpretation is much facilitated, whilst at the same time light is cast upon the more abstract similar properties of magnetic force, &c. Examples are also presented of the distinction to be drawn between E.M.F. and difference of potential, a matter which might be usefully studied by the men of standing who believe that E.M.F. *is* difference of potential always, thus putting the cart before the horse in more senses than one.

The matter to be discussed is perhaps most easily approached by starting from a very simple case, which, though not comprehensive, will lead up to the more general cases in a natural manner, and with an already attained idea of what to expect or look for, which is as valuable in theory as Faraday found it to be in experimentation. Let there be two wires in parallel arc of resistances R_1 and R_2, and let the difference of potential of their common terminals be E. By Ohm's law the currents are given by $E = R_1C_1 = R_2C_2$. This is the natural division of the whole current $(C_1 + C_2)$ supplied at one terminal and leaving at the other, when there are no intrinsic E.M.F.'s in the two wires, *i.e.*, no E.M.F. in either wire except that arising from the given difference of potential. And the energy supplied per second is $EC_1 + EC_2$, which is accounted for by RC_1^2 of heat per second in one wire, and RC_2^2 in the other.

Now, whilst the potentials of the terminals remain constant, and the supply of current keeps the same, let the current divide in some other than the natural manner. If then C_1 becomes $C_1 + c$, C_2 must become $C_2 - c$ to keep the supply constant. We have therefore, in addition to the natural current, a current of strength c flowing in the circuit formed by R_1 and R_2. Thus, as a special case, let $c = C_2$; then the current in R_2 is *nil*, and in R_1 it is $C_1 + C_2$; that is, the whole supplied current goes through one wire only.

Consider the change in the amount of heat developed in accordance with Joule's law. It is now $R_1(C_1 + c)^2$ in one one wire, and $R_2(C_2 - c)^2$ in the other. The additional heat is therefore $R_1c^2 + R_2c^2 + 2R_1C_1c - 2R_2C_2c$. But the sum of the third and fourth terms is *nil*, because $R_1C_1 = R_2C_2$. Hence the additional heat is $R_1c^2 + R_2c^2$, which is exactly what would be produced per second by the auxiliary current c if it existed alone. Thus, whether c be positive or negative, small or great, the heat is always increased by any departure from the natural division of the current, which is therefore that which makes the heat a minimum with a given supply and a given difference of potential.

Now, our auxiliary current of course requires E.M.F. to support it when we come to reality, the whole E.M.F. in R_1 being R_1c, and in R_2 being R_2c. Since this current does not alter the potential, its E.M.F. must be uniformly distributed in its circuit, the same amount in every unit of resistance. Although it is not necessary for the argument to specify any particular cause of this E.M.F., yet for distinctness we may mention one obvious method of producing it. Let the two conductors form a circle, and be of the same resistance per unit length. Along and parallel to the axis of this circle push a bar magnet. The E.M.F. generated will be uniform all round the circle, with no resulting difference of potential, and the induced current will have no tendency to leave the circle at the terminals, and so disturb the supply conditions. The original and the auxiliary currents are therefore quite independent; each E.M.F. works on its own current and not on the other, thus making the resultant heat the sum of the separate heats.

From this case we may pass to that of any system of connected linear conductors. Thus, let there be any number of terminals given, whose potentials are P_1, P_2, &c., and let them be connected together by wires in any manner. Every terminal may be connected to every other, but we need not suppose any two terminals to have more than one wire connecting them, as it would only introduce useless complication. Thus, if there are three terminals, we need not have more than three wires; with four terminals, six wires; and, in general, with n terminals, $\frac{1}{2}n(n-1)$ wires at most. Any junctions between the terminals are inadmissible, such really introducing fresh terminals. Let, in the first place, the system contain no intrinsic E.M.F.'s. Then, under the action of the differences of potential of the terminals (some of which are of course connected otherwise with sources of electricity), current enters the system at some and leaves at others. Let Q_1 be the current supplied at the first terminal, Q_2 at the second, and so on. Since in steady flow as much must leave as enters the system, we have the conditions $\Sigma Q = 0$.

Again, current Q_1 is supplied at potential P_1, Q_2 at potential P_2, and so on; hence the whole rate of supply of energy to the system is ΣPQ. But we cannot say that P_1Q_1 of energy is supplied at the first terminal, or P_2Q_2 at the second; this is indeterminate without further knowledge. To be true, Q_1 must leave at potential zero, Q_2 at potential zero, and so on; thus the result is only true in the sum. If but two terminals, we have $P_1Q_1 + P_2Q_2 = (P_1 - P_2)Q_1$ (because $Q_2 = -Q_1$), and $= E_1Q_1$, if E_1 is the *difference* of potentials or E. M. F. We may add a constant potential all round without making any difference in the energy supplied. For if p be the additional potential, the increase in ΣPQ is $\Sigma pQ = p\Sigma Q = 0$, because $\Sigma Q = 0$.

If the potentials are given at a certain number of terminals, and the supplies at the remainder, the distribution of currents in the system is exactly determinate, however complex it may be. For, if it were possible for there to be two different distributions of current, which should both be consistent with the P's having certain values at some terminals, and the Q's certain values at the remainder, it would be possible for a third distribution, viz., their difference, to exist, with the P's *nil* at some terminals, and the Q's *nil* at the remainder. But in this third distribution we should have $\Sigma PQ = 0$, owing to the vanishing of the P's at one set of terminals, and of the Q's at the remainder, *i.e.*, no energy would be given to the system. Hence, as we have supposed there to be no intrinsic E.M.F's., and as electric currents produce heat, there can be no current at all in the third distribution; hence our supposed second distribution is the same as the first, which is therefore unique. Special cases included in the above are when all the potentials and none of the supplies, or all the supplies and none of the potentials, are given. It should also be noticed that we have made use of the principle of Ohm's law in the demonstration of uniqueness, viz., when we formed the third distribution, afterwards proved to be a state of no current.

Now, the current in every conductor being determinate, the heat according to Joule's law is known. If R be the resistance of and C the current in any conductor, the heat is ΣRC^2 per second. Hence, by conservation of energy, we must have $\Sigma PQ = \Sigma RC^2$, if all the energy supplied goes to generate heat. And since $RC = E$, if E is the difference of potential between the ends of a conductor, we have also $\Sigma PQ = \Sigma EC$, the first summation referring to the terminals, the second to the conductors.

Although we thus obtain $\Sigma PQ = \Sigma EC$ through Joule's and Ohm's laws and the law of conservation, yet this equation is

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independent of Ohm's law altogether, and is true for any kind of distribution of the currents in the conductors consistent with the same supplies at the terminals. It is true when Q_1 divides in *any* manner between the conductors connected to the first terminal; Q_2 in any manner into its conductors, with the exception, of course, that in the wire connecting the second and first terminals we do not alter the current already fixed upon; and so on to the rest. Every wire has two terminals; hence, for a particular wire joining, say, P_1 with P_2, we have $P_1C_{12} + P_2C_{21} = (P_1 - P_2)\,C_{12} = E_{12}C_{12}$, and by extension to all the conductors we obtain $\Sigma PQ = \Sigma EC$. With the proper distribution according to Ohm's law we have also $\Sigma PQ = \Sigma RC^2$, and *then* conservation of energy, knowing that the heat is RC^2 for any conductor.

Now, let the currents be altered from their natural distribution, without changing the potentials and supplies, the P's and Q's. Let c_1, c_2, &c., be the currents required to be added to the old to make the new distribution, and let q_1, q_2, &c., have the same relation to c_1, c_2, &c., as Q_1, Q_2, &c., to C_1, C_2, &c. That is, q_1 is the sum of the additional currents entering the system at the first terminal. But the supplies are to be unchanged, therefore $q_1 = 0$, $q_2 = 0$, &c. Hence, $\Sigma Pq = 0$. But $\Sigma PQ = \Sigma EC$, independently of the manner of division of the Q's. Hence also $\Sigma Pq = \Sigma Ec$. Therefore $\Sigma Ec = 0$ also, or the differences of potential do no work upon the new currents.

The heat per second is now $\Sigma R\,(C + c)^2$ or $\Sigma RC^2 + \Sigma Rc^2 + 2\Sigma RCc$. But the last summation $= 2\Sigma Ec$, already proved to vanish; hence the additional heat is precisely that due to the new system of currents (c) alone. The two systems (C) and (c) are quite independent, and when they co-exist the heat equals the sum of their separate heats.

The heat of the system (c) being essentially positive, we see that the natural division of current is the one which makes the heat the least possible of all the distributions consistent with the supply conditions. With this natural distribution $\Sigma PQ = \Sigma RC^2$; in any other case ΣRC^2 is the greater. The excess proves the existence of intrinsic E.M.F.'s without difference of potential, producing a quite independent system of current. The intrinsic E.M.F.'s may be very variously arranged. Select a number of conductors forming a closed chain, and in this chain put E.M.F. of uniform amount per unit of resistance. If r be the whole resistance of the chain, and e the whole intrinsic E.M.F., we shall have $e = rc$, where c is the current to be added to the current due to difference of potential. No change will be produced in the currents in the other branches. Then we may take another chain (part of which may belong to the first), and do the same for it, and similarly for all the chains that may be made up. The final resultant will not alter the potentials or the terminal supplies.

We may pass with less difficulty than might be imagined to the corresponding question when we are concerned, not with a linear system, but with a conducting mass of any shape and size, and of any conductivity, uniform or not, with or without isotropy. Let P be the potential at any point of the bounding surface of the body, in general a function of its position, varying from point to point over the surface. We may conveniently divide the surface into unit areas, and assume the potential of such an area to be its mean potential. A unit area thus corresponds to a terminal in the former sense. Since we may take our unit area as small as we please, we shall clearly arrive at results which are correct in the limit. Let also Q be the current supplied to the body per unit area, corresponding to the former Q. Then, exactly as before, ΣPQ, with the summation extended over the whole surface, expresses the energy communicated to the body per second, the rate of working of the E.M.F.'s on the current. (Although we here have our terminals, for simplicity of diction, solely upon the exterior bounding surface of the conductor, yet what follows will not be affected by causing our conducting body to be bounded by any number of internal surfaces as well, to be counted with the exterior surface; thus we might have an infinitely extended conductor with internal electrodes to be taken for the bounding surface.)

Now, P being given over a portion, and Q over the remainder of the surface, and the resistance of every part of the body being given, and that there are no internal intrinsic E.M.F.'s, the distribution of current is determinate and is unique, as well as the distribution of potential, when Ohm's law, or its linear extensions, are followed, their characteristic being that if we cause an E.M.F. to act when there is an already existing E.M.F. with its corresponding current, the new E.M.F. produces its current just as if the other current did not exist; *i.e.*, the resultant E.M.F. corresponds to the resultant current in the same way as the separate E.M.F.'s do to their currents. In the first place, that there must be current is obvious if Q have any value not *nil* at any part of the surface, or if P is not the same all over the surface and the body has any conductivity at all. And that there can be but one distribution of current and of potential throughout the body under the given circumstances may be simply proved as formerly for a linear system. If two systems of current could exist separately with the same P at certain parts of the surface and the same Q at others, their difference would constitute a third system in which there would be no potential at certain parts of the surface and with no current entering the body through any portion of the remainder. Hence $\Sigma PQ = 0$ in this third distribution, and it is a state of no current anywhere, for heat would result if there were any with no supply of energy to produce it, since there are no intrinsic E.M.F.'s. Thus there can be but one distribution of current possible, and since Ohm's law or its extensions give the E.M.F. corresponding, if the potential is given at any part of the surface it becomes known everywhere.

Next we have to see what form the equation $\Sigma PQ = \Sigma EC$ takes. Divide the body into unit volumes, and let E and C be now the E.M.F. per unit length, and the current per unit area, these being not in general in the same direction, and therefore to be treated as vectors. Now Q is the normal component inwards of the surface current; hence, since P is scalar, PQ is the normal component of the vector PC, and we may at once apply the general theorem expressing the surface integral of a vector as a volume integral. The energy supplied to the body per second through its surface equals the sum of the energies supplied through the surface of each unit of volume. Hence $\Sigma PQ = \Sigma$ conv. PC, when the second summation extends throughout the body. Performing the operation of convergence, we have conv. PC $= \overline{EC}$ + P conv. C. But the current has no convergence, or does not accumulate anywhere; hence, finally, $\Sigma PQ = \Sigma\overline{EC}$, the first summation referring to the surface and the second to the volume it encloses.

This equation is quite independent of the nature of the conductor, or of any relation whatever between E.M.F. and current, following strictly from the property of the current that it has no convergence and of the electric force that it is the rate of decrease of the potential. But to introduce connection between E and C. Frst, if the conductor be isotropic, we have $E = RC$, where R is the resistance per unit volume, and therefore $\Sigma PQ = \Sigma RC^2$ simply, where of course R may be variable from point to point. Should isotropy not prevail, we have, instead, the three linear equations of resistance (p. 198), $X = r_{11}u + \ldots$, &c.; consequently now $\Sigma PQ = \Sigma(r_{11}u^2 + \ldots)$, the most general form. (See also p. 295). But there is no occasion whatever to use the lengthy expression for the heat, it being quite sufficient to write $\Sigma\overline{EC}$, with the understanding that E and C are related through the linear equations.

Whilst P and Q are unchanged, let the natural current be altered from C to $C + C_1$. This can only be by the addition of systems of internal current that either do not reach the surface at all, or, if so, do it tangentially, so as not to alter the surface supply; and intrinsic E.M.F. must be supplied just sufficient to keep up the new currents without difference of potentials. E becomes $E + E_1$, where E_1 bears to C_1 the same relation as E to C. The total heat becomes $\Sigma\overline{(E+E_1)(C+C_1)}$, or $\Sigma\overline{EC} + \Sigma\overline{E_1C_1} + \Sigma\overline{EC_1} + \Sigma\overline{E_1C}$, by expanding.

We can easily show that the third sum vanishes. For C_1 consists of closed tubes of current entirely within the body. Select one of these, of very small section, and sum up $\Sigma\overline{EC_1}$

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for it alone. Since C_1 is constant for the tube we obtain C_1 × line-integral of E once round the tube, and since the line-integral is the sum of differences of potential round a closed curve it vanishes. Hence $\Sigma E C_1 = 0$ for any tube, and for all.

As for the fourth sum, if the co-efficients of resistance form a symmetrical system, $r_{12} = r_{21}$, &c.; *i.e.*, if there is no rotatory property, we have $\overline{EC_1} = \overline{E_1 C}$ at every point of the mass (see p. 198). Hence $\Sigma E_1 C$ also vanishes, and the heat reduces to $\Sigma \overline{EC} + \Sigma \overline{E_1 C_1}$. That is, when the systems C and C_1 coexist, the heat is the sum of their separate heats. The heat added to the original heat by altering the current being positive, the actual distribution of current C must be that arrangement out of all consistent with the potential and supply conditions that makes the heat a minimum. Then, and only then, it equals ΣPQ.

When the rotatory property exists $\overline{E_1 C}$ is not equal to $\overline{EC_1}$; hence it is not proved that $\Sigma \overline{E_1 C} = 0$, and it requires separate treatment. Let C_2 be the current that must be added to C_1 to make the current that would correspond to the same E.M.F. E_1 if the transverse co-efficients of conductivity changed places, k_{12} becoming k_{21}, &c. Then $\Sigma \overline{E_1 C} = \Sigma \overline{EC_2}$ throughout the body, $= \Sigma PQ_2$ (surf.) + $\Sigma P \text{ div } C_2$ (vol.), where Q_2 is the normal component of C_2. Here C_1 being real, E_1 is real; but C_2 is not a system of closed currents, or div. C_2 does not vanish; neither does Q_2 necessarily vanish. The disappearance of $\Sigma \overline{E_1 C}$ does not therefore follow.

ON THE THEORY OF ELECTRO-MAGNETIC MACHINES.*

The elementary theory of simple machines producing rigorously constant currents often varies considerably from that of the more complex generators of actual practice, and facts of vital importance, such as the displacement of the brushes and the apparent increase of resistance with speed, are left without explanation.

Not only must the action of the magnetic field on the moving parts be considered, but also the secondary reactions of different parts on one another and on themselves, rendering the problem somewhat complicated.

Consider the case of a simple armature which revolves about an axis in its own plane and passing through its centre. We will suppose the magnetic field uniform and the velocity of rotation constant.

I. Let there be no electromotive force in the external circuit.

If H be the component of the magnetic field perpendicular to the axis of rotation, R the total resistance, and L the co-efficient of self-induction of the circuit, S the surface formed by the turns of wire which make up the armature, and T the time of a complete revolution, then starting with the plane of the armature perpendicular to the component H, the intensity of current at time t is given by the equation

$$I = C \epsilon^{-at} + A \sin\left(\frac{t}{T} - \phi\right) 2\pi \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

where C is a constant depending upon the initial conditions,

$$a = \frac{R}{L}, \quad A = \frac{\dfrac{2\pi S H}{T}}{\sqrt{R^2 + \dfrac{4\pi^2 L^2}{T^2}}} = \frac{E_0}{\sqrt{R^2 + \dfrac{4\pi^2 L^2}{T^2}}}$$

and ϕ is given by $\tan 2\pi\phi = \dfrac{2\pi L}{R T}$.

In general the exponential tends rapidly to zero and equation (1) approximates to

$$I = A \sin\left(\frac{t}{T} - \phi\right) 2\pi. \quad . \quad . \quad . \quad . \quad . \quad (2).$$

which represents the permanent state of things when the velocity is maintained constant.

It is seen that the E.M.F. in the circuit is *nil*, not when the E.M.F. due to the field is *nil*, but at the time $t = \phi$ T after this. The zero is then displaced in the direction of motion, and the angular displacement ($2\pi\phi$) increases when the velocity increases and when the resistance diminishes, *i.e.*, it increases with the intensity of current. This displacement vanishes when the resistance is infinite, *i.e.*, the circuit open, and has its greatest value, viz., 90° when the velocity is infinite; it is 45° when $R = \dfrac{2\pi L}{T}$.

The intensity of current varies from 0 at the time ϕ T to A at the time $\phi T + \dfrac{T}{4}$, and back to 0 at the time $\phi T + \dfrac{T}{2}$, and so on. The numerator of A is the maximum E.M.F. due to the magnetic field, an E.M.F. which increases with the velocity; and its denominator $\sqrt{R^2 + \dfrac{4\pi^2 L^2}{T^2}}$, a quantity which behaves as a resistance and is a function of the total resistance of the co-efficient of self induction and of the velocity.

It results from the variation of this apparent resistance that A does not increase indefinitely with the velocity, but tends to a limiting value $\left(\dfrac{SH}{L}\right)$ proportional directly to the surface of the armature and inversely to the co-efficient of self-induction.

The total quantity of electricity which passes in the circuit during a semi-revolution is numerically equal to $\dfrac{AT}{\pi}$, and the corresponding work is $\dfrac{RA^2T}{4}$; hence the mean intensity of current is $\dfrac{2A}{\pi}$, the mean intensity which would give the same amount of heat is $\dfrac{A}{\sqrt{2}}$, and the mean rate at which work is produced, or the the mean power, is $\dfrac{RA^2}{2}$. If the velocity be given so that the amount of work depends upon R, it is found to be a maximum when $R = \dfrac{2\pi L}{T}$, in which case, as we have seen, the angular displacement of zero is 45°; this maximum amount of work

$$W_m = \frac{\left(\dfrac{2\pi S H}{T}\right)^2}{4R} \frac{T}{2} = \frac{\pi S^2 H^2}{4L}$$

(remembering that $RT = 2\pi L$) the corresponding value of A being $\dfrac{SH}{\sqrt{2}L}$. If, however, the resistance be given and T variable, the mean power evidently increases with A, but we have seen that A increases with the velocity and tends to the limit $\dfrac{SH}{L}$. Substituting this value, we have for the maximum power (which is reached when the velocity is infinite) $R\dfrac{S^2H^2}{2L^2}$, which is double of the value corresponding to the condition $RT = 2\pi L$.

Taking for example $R = 10 \times 10^9$, $L = \cdot 3 \times 10^9$, $S = 1{\cdot}25 \times 10^6$, and $H = 100$ in C.-G.-S. units, and $T = \cdot 1$, *i.e.*, 10 revolutions per second, we have $\phi = \cdot 172$ or $2\pi\phi = 62°$, and $A = 3{\cdot}68$ amperes. The mean intensity is 2·344 amperes and the limiting value of A 4·166 amperes. The resistance which, for the given velocity, would correspond to the maximum work is 18·85 ohms. If it be required to find the diameter of the wire with which the armature must be wound in order to obtain the greatest current, the dimensions of the armature and the external resistance r' being given, let r_1 L_1 S_1 be the new values of the resistance, co-efficient of self-induction and surface of the turns of wire when wound with a wire n times the diameter of the original, then $r_1 = \dfrac{r}{n^4}$, $L_1 = \dfrac{L}{n^4}$ and $S_1 = \dfrac{S}{n^2}$. The greatest current is obtained when

$$n^8 = \frac{r^2 + \dfrac{4\pi^2 L^2}{T^2}}{r'^2}$$

$$\text{and } r_1 = r' \sqrt{\frac{r}{r^2 + \dfrac{4\pi^2 L^2}{T^2}}}.$$

Applying these formulæ to the particular armature considered

* Abstract of a paper by Professor M. J. Joubert, in the *Journal de Physique*, No. 19, July, 1883.

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above, and taking $r' = 5$ ohms, $T = \cdot 1$, we have $n = 1\cdot 406$ and $r_1 = 1\cdot 3$ ohm. The value of A then becomes 5·02.

In order to collect the alternating currents in such a way that they shall always traverse the external circuit in the same direction, it is necessary to employ a commutator, as, for instance, a ring divided along a diameter into two parts insulated from each other, and each connected to an end of the wire, and against which rub two brushes on opposite sides, the ring itself being connected to the axis and revolving with the armature. If the plane of section of the ring coincide with the plane of the armature, the instant at which commutation takes place will depend upon the position of the brushes.

The interval between the commencements of successive commutations is plainly equal to $\frac{T}{2}$. It consists of two parts: the first, during which each brush presses against a separate half of the ring, begins at a time ψT after the passage of the armature across the plane perpendicular to H, with an intensity of current I_0, and ends at the time $\psi T + \frac{T}{2} - \chi T$ with an intensity I_1; the second, during which the brushes change their contact, lasts a time χT, beginning with the intensity I'_1 and ending with I_2. We have here two cases. In the one the commutation is accompanied by an interruption of the circuit, the division of the ring being so wide that during the time χT the brushes are in contact with neither half of the ring; in the other there is no interruption, but during the time χT each brush touches both halves of the commutator, and the two circuits are for that period in parallel arc.

In the first case it is found that the energy which must be supplied by external forces to keep up the motion of the armature is greater than the energy obtained in the circuit by a quantity $\frac{1}{2} L (I_1^2 - I_0^2)$ which represents the loss due to commutation, and shows itself in the form of a spark; in fact, the spark prolongs the current after the circuit has been broken. This loss of energy can be diminished by making I_1 as nearly as possible equal to I_0, *i.e.*, by making χT as short an interval as possible, or in other words by narrowing the division between the two parts of the ring. Again, the interval ψT may be chosen of such a length as either to make the quantity of electricity flowing in the circuit a maximum, or to break the circuit at the instant when the intensity is *nil*, and thus avoid sparking. For the first condition we must have

$$\tan 2\pi(\psi - \phi) = \frac{\sin 2\pi\chi - (1 - \epsilon^m)\tan 2\pi\phi}{1 + \cos 2\pi\chi}$$

where $m = -\frac{R}{L}(\frac{1}{2} - \chi)\,T$, in which case the loss of energy is $L I_1^2$ per revolution; and for the second condition

$$\tan 2\pi(\psi - \phi) = \frac{\sin 2\pi\chi}{\epsilon^m + \cos 2\pi\chi}.$$

In the second case, which is that of ordinary practice, if r be the resistance of the external circuit, putting as before

$$a = \frac{R}{L},\ \tan 2\pi\phi = \frac{2\pi L}{RT},\ A = \frac{\frac{2\pi S H}{T}}{\sqrt{R^2 + \frac{4\pi^2 L^2}{T^2}}}$$

$$a' = \frac{r}{L},\ \tan 2\pi\phi' = \frac{2\pi L}{rT},\ A' = \frac{\frac{2\pi S H}{T}}{\sqrt{r^2 + \frac{4\pi^2 L^2}{T^2}}}$$

The equations for the intensity of current corresponding to the two parts of the semi-revolution are

$$I = C\epsilon^{-at} + A\sin 2\pi\left(\frac{t}{T} - \phi\right)$$

$$I' = C'\epsilon^{-a't} + A'\sin 2\pi\left(\frac{t}{T} - \phi'\right)$$

and to determine the constants we have

$$I_0 = C\epsilon^{-a\psi T} + A\sin 2\pi(\psi - \phi)$$

$$I' = C\epsilon^{-a(\psi + \frac{1}{2} - \chi)T} - A\sin 2\pi(\psi - \phi - \chi)$$

$$I_1' = C'\epsilon^{-a'(\psi + \frac{1}{2} - \chi)T} - A'\sin 2\pi(\psi - \phi' - \chi)$$

$$I_2 = C'\epsilon^{-a'(\psi + \frac{1}{2})T} - A'\sin 2\pi(\psi - \phi')$$

but it must be noticed that when once regularity is established $I_2 = -I_0$, and the last equation becomes

$$I_0 = -C'\epsilon^{-a'(\psi + \frac{1}{2})T} + A'\sin 2\pi(\psi - \phi').$$

When $\chi = 0$ we have $I_1 = I_0$, and consequently $C = 0$, and the equation for intensity coincides with that corresponding to the permanent state, the commutator merely serving to change the direction of the current in the external circuit, a circuit free from induction. The quantity of electricity which traverses the circuit in one direction during a semi-revolution is $\frac{AT}{\pi}\cos 2\pi(\psi - \phi)$, and is greatest when $\psi = \phi$ and zero when $\psi = \frac{1}{2} + \phi$.

When χ is not zero put $\epsilon^{-a(\frac{1}{2} - \chi)T} = \epsilon^m$, $\epsilon^{a'\chi T} = \epsilon^n$

$$D = \epsilon^m + \epsilon^n,\ F = \left\{\cos 2\pi(\phi + \chi) - \epsilon^n\cos 2\pi\phi - \frac{A'}{A}\left[\cos 2\pi(\phi' + \chi) - \epsilon^n\cos 2\pi\phi'\right]\right\}$$

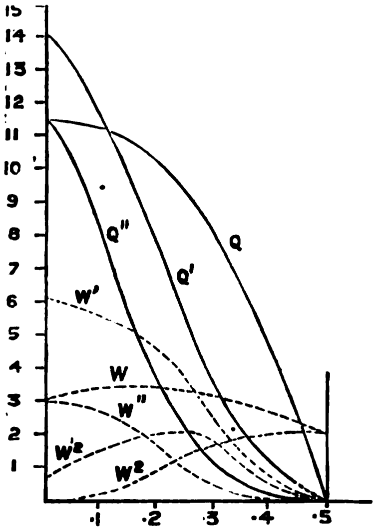
$$\times \frac{1 - \epsilon^m}{D}\tan 2\pi\phi + \sin 2\pi(\phi + \chi) + \sin 2\pi\phi$$

$$G = -\left\{\sin 2\pi(\phi + \chi) - \epsilon^n\sin 2\pi\phi - \frac{A'}{A}\left[\sin 2\pi(\phi' + \chi) - \epsilon^n\sin 2\pi\phi'\right]\right\}$$

$$\times \frac{1 - \epsilon^m}{D}\tan 2\pi\phi + \cos 2\pi(\phi + \chi) + \cos 2\pi\phi$$

Then the quantity of electricity which traverses the external circuit in each semi-revolution is $\frac{AT}{2\pi}(G\cos 2\pi\psi + F\sin 2\pi\psi)$ which has its greatest value $\frac{AT}{2\pi}\sqrt{F^2 + G^2}$ when $\tan 2\pi\psi = \frac{F}{G}$

The figure shows the results of the different methods of commutation applied to the armature taken as an example above.



The curves Q represent the quantity of electricity per period (·1 coul. to a division), W the total electro-magnetic work (·1 kgm. to a division), and W_2 the work lost. The letters without accent refer to the case in which the circuit is never broken, with one accent to that in which the position of the brushes is determined by the condition that the current should be a maximum, and with two when the brushes are so placed that there is no spark.

II. Let there be an electromotive force in the external circu .

First, consider a constant electromotive force, that of a battery for example. We have for the resulting current as soon as regularity is established, there being no commutation, $I = A\sin\left(\frac{t}{T} - \phi\right)2\pi + \frac{E}{R}$. The current due to the machine and that due to the battery are evidently alternately of the same and of opposite sign, and whether the resulting current be alternating or continuous depends upon the relative values of the two E.M.F.'s. The effect on a galvanometer placed in the circuit is exactly the same as if the battery were acting alone in a circuit at rest,

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which experiment furnishes a complete verification of Ohm's law. The total energy produced in the circuit in a complete revolution is exactly the same as that of the battery acting alone. The machine can only produce a useful result if the direction of one of the electromotive forces be reversed at each semi-revolution. This is accomplished automatically if the external E.M.F. be one of polarisation, such as an electric arc or a voltameter. Now, the electromotive force of polarisation at any instant is proportional to the quantity of electricity which has traversed the circuit. If we put $\epsilon = 2\phi \Sigma q$, then when $\frac{2\pi L}{T} - \frac{\phi T}{2\pi} = 0$, it is found that the effect of polarisation and that of the action of the circuit on itself destroy each other, and the equation for the current reduces to $I = \frac{E_0}{R} \sin \frac{2\pi t}{T}$ (E_0 being E.M.F. of induction produced in armature when its plane is proportional to H).

Now, consider the external electromotive force constant, but the machine furnished with a commutator. We have then, as before, two parts of the semi-revolution, one lasting a time ψT during which the armature and the external circuit are connected in series, and the other χT during which each is short circuited by the brushes, so that it can be considered as an independant circuit. The equations for the current corresponding to these two parts are

$$I = \frac{E}{R} + A \sin 2\pi \left(\frac{t}{T} - \phi\right) + C \epsilon^{-at}$$

$$I' = A' \sin 2\pi \left(\frac{t}{T} - \phi'\right) + C' \epsilon^{-a't}.$$

When $\chi = 0$, we have

$$I = A \sin 2\pi \left(\frac{t}{T} - \phi\right) + \frac{E}{R} - 2\frac{E}{R} \frac{\epsilon^{a\psi T}}{1 + \epsilon^{-a\frac{T}{2}}} \epsilon^{-at},$$

and the quantity of electricity which passes in a semi-revolution,

$$q = \frac{AT}{\pi} \cos 2\pi (\psi - \phi) + \frac{ET}{2R} - \frac{2EL}{R^2} \frac{1 - \epsilon^{-a\frac{T}{2}}}{1 + \epsilon^{-a\frac{T}{2}}},$$

which is a maximum when $\psi = \varphi$, but the electro-magnetic work is

$$\frac{A^2 RT}{2} + \frac{AET}{\pi} \cos 2\pi (\psi + \phi),$$

which is a maximum when $\psi = -\phi$, whence it follows that in order to get the most current the brushes must be displaced in the direction of motion through an angle $2\pi\phi$, determined by $\tan 2\pi\phi = \frac{2\pi L}{RT}$, but to get the most electro-magnetic work through the same angle in the opposite direction.

If the two electromotive forces act in opposite directions, the machine works as a generator or motor, according as E_0 is greater or less than E. In the first case ψ must be chosen so as to give the maximum current, in the second so as to give the most work.

In the case of a motor, if the dimensions of the armature be given, and T determined so as to make the power a maximum, it is found that $A = \frac{2E}{R}$; but A can never be greater than $\frac{SH}{L}$, so that unless $\frac{SH}{L} > \frac{2E}{\pi R}$, this maximum power cannot be obtained. In other words, if $\frac{SH}{L} > \frac{2E}{\pi R}$, T should be determined from $A = \frac{2E}{R}$, and if $\frac{SH}{L}$ be not greater than $\frac{2E}{\pi R}$, the faster the machine runs the better.

When χ is not zero, it is found that the work is only slightly diminished as long as χ is not greater than $\frac{1}{5}$ of the semi-revolution, but after that it falls rapidly; so that χ should be as small as possible, but so long as it is not greater than $\frac{1}{5}$ the results obtained are not very different from those on the supposition that $\chi = 0$.

A HISTORY OF ELECTRIC TELEGRAPHY TO THE YEAR 1837.

BY J. J. FAHIE, MEMB. SOC. TEL. ENGS. AND ELECS.*

CHAPTER III.—TELEGRAPHS BASED ON STATIC, OR FRICTIONAL, ELECTRICITY.

(CONTINUED FROM PAGE 335.)

Phosphorus and other combustible substances were next tried, but nothing was found to succeed so well as a mixture of inflammable and common air, confined in specially prepared flasks. Having made this discovery, Cavallo next directed his attention to the best means of insulating the communicating wire, and at last so contrived that it might be laid indifferently on wet, or dry, ground, or even through water.

"A piece of annealed copper, or brass, wire," he says, "being stretched from one side of a room to the other, heat it by means of a flame of a candle, or of a red-hot piece of iron, and, as you proceed, rub a lump of pitch over the part just heated. When the wire has been thus covered, a slip of linen rag must be put round it, which can be easily made to adhere, and over this rag another coat of melted pitch must be laid with a brush. This second layer must be covered with a slip of woollen cloth, which must be fastened by means of a needle and thread. Lastly, the cloth must be covered with a thick coat of oil paint. In this manner many pieces of wire, each of about twenty, or thirty, feet in length, may be prepared, which may afterwards be joined together, so as to form one continued metallic communication; but care must be taken to secure the places where the pieces are joined, which is most readily done by wrapping a piece of oil-silk over the painted cloth, and binding it with thread. When a long wire has been thus made out of the various short pieces, let one end of it be formed into a ring, and to the other adapt a small brass ball.

"Through the wires so prepared the flask of inflammable air was always exploded, and whenever the discharge was passed through a flask of common air a spark was seen, and by sending a number of such sparks at different intervals of time, according to a settled plan, any sort of intelligence might be conveyed instantaneously from the place in which the operator stands to the other place in which the flask is situated."†

"With respect to the greatest distance to which such communication might be extended," concludes Cavallo, "I can only say that I never tried the experiment with a wire of communication longer than about two hundred and fifty feet; but from the results of those experiments, and from the analogy of other facts, I am led to believe that the above-mentioned sort of communication might be extended to two, or three, miles, and, probably, to a much greater distance."

1795-8.—SALVÁ'S TELEGRAPH.

Of all the pioneers of the electric telegraph in the last century, Don Francisco Salvá, of Barcelona,‡ deserves the most honourable mention, as well for the extent and completeness of his designs, as for the zeal and intelligence with which he carried them out. His proposals are described with great clearness in a memoir which he read before the Academy of Sciences, Barcelona, December 16, 1795, and from which we cannot do better than make some extracts:§—

"If," he says, "there were a wire from this city to Mataro, and another from Mataro back, and a man were there to take hold of the ends, we might, with a Leyden jar, give him a shock from this end, and so advise him of any matter previously agreed on, such as a friend's death. But this is not enough, as, if electricity is to be of any use in telegraphy, it must be capable of communicating every kind of information whatsoever; it must,

* The author reserves all rights of translation.

† Moigno ("Télégraphie Electrique," page 61) says Cavallo proposed to express signals by the explosion, by the spark, of such substances as gunpowder, phosphorus, phosphuretted hydrogen, &c., but this is an error.

‡ Don Francisco Salvá y Campillo was born at Barcelona, July 12, 1751. After graduating, with honours, in the universities of his native place, of Valencia, of Huesca, and of Tolosa, he travelled in Italy, France, and other parts of the Continent, and made the acquaintance of many of its learned men, including Le Sage, Reusser, and other well known electricians. Besides being an able electrician, Salvá was a distinguished physician, and ardently promoted the cause of vaccination in Spain. He died February 13, 1828. See Saavedra's *Biography* in the *Revista de Telégrafos* for 1876.

§ Translated from Saavedra's "Iratado de Telegrafia," 2nd ed., pp. 119-24 of Vol. I.

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in a word, be able to speak. This is happily of no great difficulty.

"With twenty-two letters, or even with eighteen, we can express, with sufficient precision, every word in the language, and thus, with forty-four wires from Mataro to Barcelona, twenty-two men there, each to take hold of a pair of wires, and twenty-two charged Leyden jars here, we could speak with Mataro, each man there representing a letter of the alphabet, and giving notice when he felt the shock. Let us suppose that those receive shocks who represent the letters p, e, d, r, o, we shall then have transmitted the word Pedro. All this is within the limits of possibility; but let us see if it cannot be simplified.*

"It is not necessary to keep twenty-two men at Mataro, nor twenty-two Leyden jars at Barcelona, if we fix the ends of each pair of the wires in such a way that one or two men may be able to discriminate the signals. In this way six, or eight, jars at each end would suffice for intercommunication, for, of course, Mataro can as easily speak with Barcelona, as Barcelona with Mataro.

"It appears, however, little short of impossible to erect and maintain so many wires, for, even with the loftiest and most inaccessible supports, boys would manage to injure them; but as it is not necessary to keep them very far apart, they can be rolled together in one strong cable, and placed at a great height. In the first trials made with a cable of this kind I covered each wire with paper, coated with pitch, or some other idio-electric substance, then, tying them together, I bound the whole with more paper, which effectually prevented any lateral escape of the electricity. In practice the wire cable could be laid in subterranean tubes, which, for greater insulation, should be covered with one or two coats of resin."

In selecting Barcelona and Mataro, distant about thirteen miles, Salvá did not imply that this was the limit at which his telegraph would be practicable; on the contrary, he thought it very probable that the distance at which the electric discharge would be effective was proportional to the number of jars, and, therefore, that with a large battery telegraphic communication may be established between Barcelona and Madrid, and even between places one hundred, or more, leagues apart.

After showing the superiority of an electric telegraph over the optical (semaphore) system then in use, he lays special stress on the advantages of the former as regards communication between places separated by the sea, and adds:—

"In no place can the electric telegraph [wires] be better deposited. It is not impossible to construct, or protect, the cables with their twenty-two [pairs of] wires, so as to render them impervious to the water. At the bottom of the sea their bed would be ready made for them, and it would be an extraordinary casualty indeed that should disturb them * * * * * *

"In 1747, Watson, Bevis, and others, in England, showed how the water of the Thames may be made to form part of the circuit of a Leyden jar, and this makes us consider whether it would not suffice for our telegraph to lay a cable of twenty-two wires only across the sea, and to use the water of the latter in place of the twenty-two return wires."†

In the experiments with which Salvá illustrated his paper, he indicated the letters in a way which, by some strange mistake, has always been ascribed to Reusser. The seventeen essential letters of the alphabet (for he omitted those little used, or whose power could be represented by others) were cut out of parallel strips of tin-foil, pasted on bits of glass, after the fashion of spangled panes, and to the ends of each piece of tin-foil were attached the extremities of the corresponding pair of wires. All the wires were bound up in two cables, which were prepared in the way before described, the out-going wires being collected in one cable, and the return wires in the other.

To indicate a letter, A. for example, it was only necessary to take the ends of the corresponding pair of wires, and connect one end with the outer, and the other with the inner coating of a charged jar. Immediately on thus completing the circuit, the observer, at the other end of the cable, heard the noise of the spark, and saw it illuminate the letter, A. in its passage across the breaks in the tin-foil.*

From 1796 to 1799 Salvá resided at Madrid, having been invited by the Academy of Sciences of that capital to engage in some experiments of great public interest. There he had the *entrée* of all the *salons*, and was courted by everybody of consideration—amongst the rest, by the Infante Don Antonio, who appears to have assisted him in perfecting his telegraph. The favourite Godoy, Prince of Peace, was another good friend, to whom Salvá was indebted for an introduction to the King, Charles IV., as we learn from the following paragraph in the *Gaceta de Madrid*, November 29, 1796:†—"The Prince of Peace, who testifies the most laudable zeal for the progress of the sciences, understanding that Dr. Francisco Salvá had read at the Academy of Sciences, at Barcelona, a memoir on the application of electricity to the telegraph, and presented at the same time an electrical telegraph of his own invention, requested to examine the apparatus himself. Satisfied with the exactness and celerity with which communications may be made by its means, he introduced the doctor to the King of Spain. The Prince of Peace afterwards, in the presence of their Majesties and the whole court, made some communications with this telegraph, completely to their satisfaction. The Infante Don Antonio proposes to have one of them of the most complete construction, which shall posses power sufficient to communicate between the greatest distances, by land or sea. With this view, his Highness has ordered the construction of an electrical machine, the cylinder of which is to be more than 40in. in diameter. He intends, as soon as it is finished, to undertake a series of curious and useful experiments, in conjunction with Dr. Salvá. This is an employment worthy of a great prince. An account of the results will be given to the public in due course."

Notwithstanding this promise, the subject is not again referred to in any succeeding number of the *Gaceta*; but according to Dr. Balcells, the friend of Salvá, a modification of his telegraph which required only one wire was actually constructed in 1798 between Madrid and Aranjuez, a distance of about twenty-six miles. Humboldt, at page 14 of Gauss and Weber's "Resultate" for 1837, refers to this line, but credits it to Bétancourt, a French engineer. This is clearly a mistake, into which the great traveller might have been led by the probable fact that an engineer of that name was employed to superintend the work—a supposition which is likely enough seeing the greatness of the undertaking.

Dr. Balcells, whose evidence as just quoted should be conclusive on this point, says, further, that the remains of Salvá's telegraph, which, at first, were destined for Don Antonio's museum, were presented, in 1824, to the College of Pharmacy of San Fernando, of which he (Balcells) was then the Adjutant (Saavedra, Vol. I., page 124).

(TO BE CONTINUED.)

* Zetzsche ("Geschichte der Elektrischen Telegraphie," p. 21) says no attempt has been made to construct a telegraph with the physiological effects of static electricity for its basis. Salvá's is an early example; here is another, though of a negative kind. The Rev. J. Gamble, in his excellent treatise on Semaphoric Telegraphs, says, in reviewing the different modes of communication that had been proposed up to his time:—

"Full as many, if not greater, objections will probably operate against every contrivance where electricity shall be used as the vehicle of information. The velocity with which this fluid passes, where the conductors are tolerably perfect, and also that it may be made to pass through water to a very great distance, when it forms part of the circuit, are properties which appear to have given rise to the idea of using it as a means of correspondence. I have never [? even] heard it mentioned, that an alarm may be given to a very great distance, by firing a pistol charged with inflammable air, which explodes by the smallest spark of electricity; but the further communication could only be maintained by a certain number of shocks being the preconcerted signal of each letter, and requires that the man who receives the intelligence should remain constantly in the circuit of the electric fluid. The whole success of the experiment would likewise depend on an apparatus liable to an infinite number of accidents, scarce in the power of human foresight to guard against." *Essay on the different Modes of communication by Signals*, London, 1797, p. 73. We will meet with other examples further on.

† Because Baron Schilling, of St. Petersburg, used a "subaqueous galvanic conducting cord" across the river Neva in 1812, and, in 1837, proposed to unite Cronstadt with the capital by means of a submarine cable, he has been called the Father of submarine telegraphy (Hamel's "Historical Account," &c., pp. 16 and 67, of W. F. Cooke's reprint). But Salvá, to say nothing of Cavallo, was, as we here see, at least seventeen years before him, and to Salvá, therefore, belongs the honour which has hitherto been accorded to the Russian philosopher. As we shall see in a future chapter, this is not the only case in which honours justly due to Salvá are unjustly heaped on another.

* "The late Dr. Balcells, professor in the Industrial School of Barcelona, whose acquaintance I made towards the latter years of his long life, and who, in his turn, had known the celebrated physicist, Salvá, has often assured me that the apparatus just described was tried by its inventor from the Academy of Sciences to the Fort of Atarazanas, across the Ramblas, a distance of about a kilometre." (Saavedra. "Iratado de Telégrafia," 2nd Ed. Vol. I., p. 122.)

† First translated into English in *The Monthly Magazine*, for February, 1797, page 148. Also noticed in Voigt's *Magazin*, for 1798, Vol. XI., Part IV., page 61. As a curiosity of book-making, we may observe that, in every account of Salvá's telegraph that we have seen, the extracts from the Madrid *Gaceta* and Voigt's *Magazin* are given as if they referred to two entirely different affairs, the latter being usually rendered as follows:—Voigt's *Magazin*, in reference to these experiments, announced two years afterwards that Don Antonio *constructed* a telegraph upon a very grand scale, and to a very great extent. *It also states that the same young Prince was informed at night, by means of this telegraph, of news that highly interested him!* See Highton's "Electric Telegraph: Its History and Progress," London, 1852, p. 43, as a case in point.

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ANSWER TO CORRESPONDENT.

J. W. LEWIS (Bristol).—*The price of A Practical Treatise on Electricity, &c., is £2 2s. It is published by Sampson Low and Marston, Fleet street, E.C. (vide our advertisement columns).*

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GUARDING AGAINST MONOPOLIES.

Under the somewhat bombastical title of "On Guard Against Monopolies," a high-class newspaper one day last week spoke its final word concerning electric light monopolies, and on the same day two other organs of public, or political, opinion delivered themselves in equally emphatic terms, but in entirely opposite senses. The electric light, as we have before remarked, has fallen in difficult times, not the least inconvenient phase of which is the political bias with which every question, social, commercial, or domestic, is nowadays discussed. These three utterances are types of many that have preceded, and patterns of more that will follow them. For a fair and impartial examination of the subject in question we have looked, and looked in vain, among the journals which profess to educate, and do actually influence, the public mind. Hostility to the Government in power marks the utterances of one, rash and pretentious dogmatism pervades another, whilst a third is ready with eulogies for any and every measure that bears the official brand. Promoters of electric lighting had need to be philanthropists, besides being honest traders, to find their account in times like these.

One of the newspapers we refer to affects to be greatly scandalised at the announcement made by an assistant secretary of the Board of Trade, that the board had decided to refuse to grant licenses for the lighting of large areas involving considerable outlay of capital. As a matter of fact, the board has only reserved to itself the power of veto on the choice of the local authorities. We are not enamoured of the legislation instituted by the Board of Trade in respect to electric lighting; but it is impossible to understand the functions of the board unless they include, and, when needful, exercise this right of veto; for if the board is to endorse every license asked for by the vestries, its endorsement might just as well be dispensed with altogether. The newspaper in question, not being a thick and thin supporter of the Government, and having, besides, its own particular ends to serve, calls this a surprise sprung upon the companies at the last moment. The frightful consequence of the decision—or, rather, as we should say, explanation—of the Board of Trade is described as devolving the responsibility of all the most important engagements of this kind upon Parliament. It certainly does so, and nobody ought to be surprised. Those who were not content to let electric lighting proceed in a natural way without the artificial stimulus of an Act of Parliament have no right to complain that parliamentary control is a reality, or that the words "empowered to grant" do not necessarily mean "compelled to grant."

On the same day a thoroughgoing partisan organ found cause for jubilation in the barriers, safeguards, and restrictions which the measure, now that it is seen at work, vexatiously imposes on electric lighting enterprise. Perhaps we should rather say companies, for it is not the enterprise, but the people who display it, that provokes this hostility. Call yourselves a company, and you have a sure enemy in the organ of philosophical radicalism. The electric lighting companies were launched, of course, with the sinister design of creating monopolies. Mr. Chamberlain has frustrated their attempts at every turn. They have been warned from stage to stage that the Bill would create no monopoly in any shape whatever; there has, therefore, been no misunderstanding and no "surprise." So hedged round was the enactment with provisos and stipulations by those vigilant officers of the Board of Trade who were "on guard against monopolies," that the wonder is that anybody has been venturesome enough to ask for what is granted, with such pains and penalties attached to it. Even the House of Lords is complimented for adding one fresh obstacle to the creation of a monopoly. There is to be no fixity of price, nor of tenure, nor of obligation either. In short, if all that is claimed for these interpretations of the Act prove to be correct, electric lighting for profit will be rendered well-nigh impossible, simply in order to guard against the bugbear monopoly. All this—the fencing round of concessions with stringent limitations—is, we are told, a healthy sign. That is to say, it is healthy from the political standpoint of our able contemporary. We have no business to argue with it on its own ground; but in commercial affairs mistrust and want of confidence are regarded as the reverse of healthy; and it is just possible that, if the gas and water companies had been trammelled originally with conditions and penalties such as are now freely imposed on the electric companies, we might have had no gas and no water to complain about. If the Act confers no monopoly, it is hard to understand why any Act was required, except as a warning to all future would-be monopolists.

The true explanation of the several checks experienced by

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the provisional orders before and after they reached the House of Lords is probably to be found not in an improved healthy tone, political or commercial, nor in any strong prejudice against monopolies, but in a prevailing suspicion, growing stronger every day, that the original Act was precipitately framed, and was, perhaps, a little prematurely passed. A third newspaper, however, would have us believe the exact contrary. Nothing could be more opportune than the passing of the Act, for after being laid aside for a number of years as a scientific toy, the electric light had suddenly blazed forth into usefulness as well as beauty, perfect in every respect, and ready to be utilised by rich and poor alike. We are now quoting from a high authority on Government measures, and a still higher on financial matters. It has aspired lately to be also an authority in science—especially the science of storing electricity by means of certain contrivances devised by certain inventors whom it carefully specifies, and without which, we are informed, the electric light would have continued to be the mere toy it once was. Here the political, the financial, and the scientific elements work harmoniously together. We are blessed with the most perfect of all Governments; the electric accumulators of Brown, Jones, and Robertson—to say nothing of Smith's, which may also have some merits, for it will not do to seem one-sided—are everywhere in use, and are "admittedly" economical. The readers of this journal, therefore, are troubled with no misgivings such as may be supposed to afflict the readers of the other two. Besides knowing whom to vote for, they know exactly where to invest their money, and they get a lesson in electrical science thrown in. It is not always that a party organ is able to combine political fidelity with commercial zeal, and the opportunity is not lost.

A fitting commentary upon these various utterances was furnished only two days after by the letter of Mr. Henry G. Calcraft, one of the secretaries of the Board of Trade, in which he explains why the granting of licenses to electric lighting companies "for wide areas, such as the whole of a provincial town or of a London parish," is for the present withheld. According to the terms of the Act such licenses could only be granted for a term of seven years; probably two or three years would elapse before such undertakings would be in full operation. There would remain, therefore, only four or five years for the undertakers to reap the fruits of their enterprise, and during this time they would be exposed to severe competition from the gas companies. "It is difficult," says Mr. Calcraft, "to believe that under such circumstances prudent and capable investors will be found able and willing to provide the capital necessary for so large and hazardous an undertaking; and that which is unsafe and imprudent for investors can seldom be for the ultimate good of the public;" hence the board has decided to ratify licenses only for small areas. The ludicrous consequence of being "on guard" against monopoly could hardly be better illustrated; and it foreshadows, as we predicted would be the case, the utter break down of the Act. What the board now says is what every sensible man said at the time—a seven years' license was a delusion to begin with, and must have ended in a fraud. The board now virtually confesses that unless it grants a monopoly no ultimate good to the public can be obtained. The confession comes very late, and electric lighting companies have great cause to complain of their treatment at the hands of a department which has sacrificed them and the public in obedience to a political fad. But if it result in an emendation of the Act, the incident is, perhaps, not altogether to be regretted.

THE ELECTRIC RAILWAY AT THE CHICAGO EXPOSITION.*

It is not too much to say that the electric railway which was in operation at the recent exposition of railway appliances at Chicago constituted the leading novelty and one of the chief features of attraction of that magnificent display of the sciences and arts applied to the railroad. We may go even further, and say that a railway exposition on such a grand scale would have been incomplete had it failed to embody the electric railway—the latest development of the art, the newest phase of evolution of the locomotive. The locomotives of the past were there, cumbrous, clumsy specimens of mechanical construction, which left one in doubt whether such crude affairs ever did or could move themselves without assistance. The locomotive of the present was also there, under many a type—marvels of engineering science and skill, from the Rogers, the Baldwin, and all other locomotive works of the land, all vieing with each other in perfection of design and beauty of workmanship. The locomotive of the future—the electric railway—was therefore needed to complete the list. It did not appear there to best advantage; for we shall see presently that it was called into existence for the occasion at very short notice, and under adverse circumstances. Still, it answered every purpose as a suggestion of the great capabilities which lie in its way. The visitor who had followed the history of the steam locomotive by passing successively from the oldest type to the youngest, and now paused before the electric locomotive in wonder, could scarcely refuse to believe that here was a new and higher plane of evolution, of which the specimen before him was but the merest beginning—the protoplasm. And involuntarily the conviction came to his mind that if the earliest and crudest electric locomotive could boast of such a successful performance, surely the products of the future Rogers and Baldwins of electric railway construction would surpass all anticipations of success. The electric railway at Chicago has already been described briefly by the scientific press throughout the country, but we have purposely delayed giving any detailed description until the present time, in order to be able to produce a complete and satisfactory account of it, accompanied by a series of original illustrations and diagrams, which we take pleasure in presenting to our readers.

When we consider the remarkably short time in which this electric railway was constructed and put in operation, it seems like a great achievement. The Electric Railway Company of the United States, which was formed to acquire and consolidate the Field and Edison patents, did not properly come into existence until about the beginning of May. The project of exhibiting at the Chicago exposition had been entertained, but it was not until two weeks before the opening of this exposition that it was definitely decided that the electric railway should form one of its features. Everything remained to be prepared. The locomotive was scarcely begun, and the track was not laid. But the work was put under way and pushed with vigour. It is needless to say that the electric railway, under the circumstances, does not fairly represent the inventions of Messrs. Field and Edison, because the short time allowed to complete preparations left no other alternative than to make use of such electrical apparatus and material as could be readily and conveniently procured in the market, without stopping to inquire too closely into its fitness for the purpose, and then to design everything else to suit its electrical and mechanical peculiarities. Under the circumstances, it was impossible to hope for great efficiency or economy of results. It is, indeed, a matter of surprise that an electric railway was produced at all from the resources available in that time, and it reflects the greatest credit upon Mr. Frank B. Rae, one of the electrical engineers of the company, who had charge of the enterprise, and Mr. Clarence L. Healy, his assistant, who personally attended to many details.

As the short time did not permit of the construction of

* We are indebted to the courtesy of the editor of the *Electrical World* of New York for this article and the illustrations.

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dynamo-electric machines especially adapted to perform the functions of generator and motor, some Weston machines were procured for this purpose from the United States Electric Lighting Company, of New York, which had an exhibit at the exposition. The same type of machine was used as generator and as motor. It was what is known as the No. 6 Weston 100 incandescent light machine, having an electromotive force of about 75 volts at its

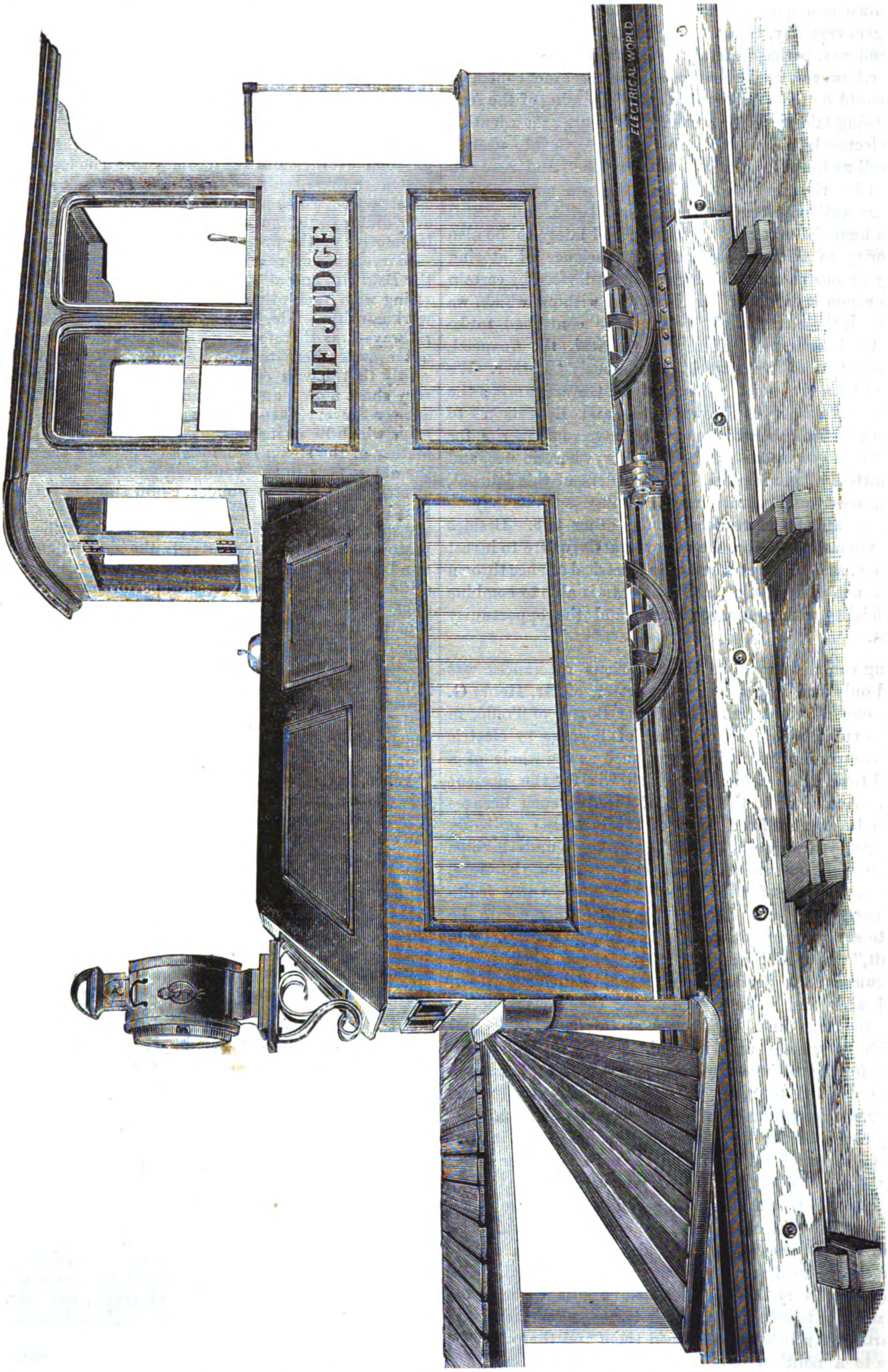

FIG. 1.—THE ELECTRIC LOCOMOTIVE AT THE CHICAGO EXPOSITION.

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normal speed of 1,100 revolutions, and producing a current of about 150 amperes through its normal circuit resistance of ·5 ohm. Its weight was 2,700lbs. This electromotive force was comparatively low, and it was necessary to use great care to make the resistance of the track and connections a minimum.

Our first illustration represents the electric locomotive "The Judge" upon the track. The passenger car, which was similar in appearance to an open street car, is not shown. The locomotive was styled "The Judge" by Mr. Field himself, who claimed the privilege of baptising this child of his genius, in honour of his uncle, Chief Justice Field.

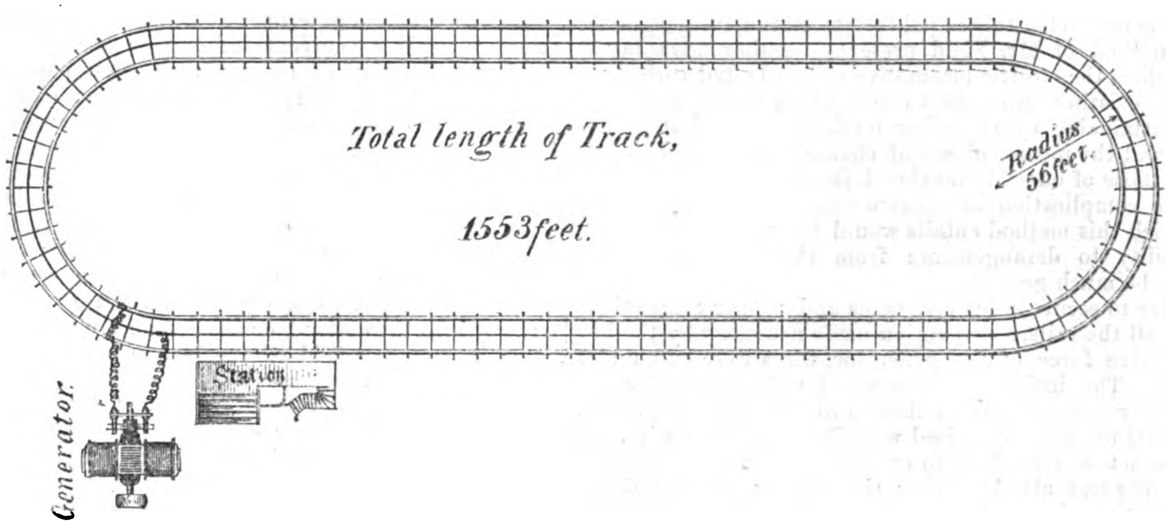

Fig. 2.

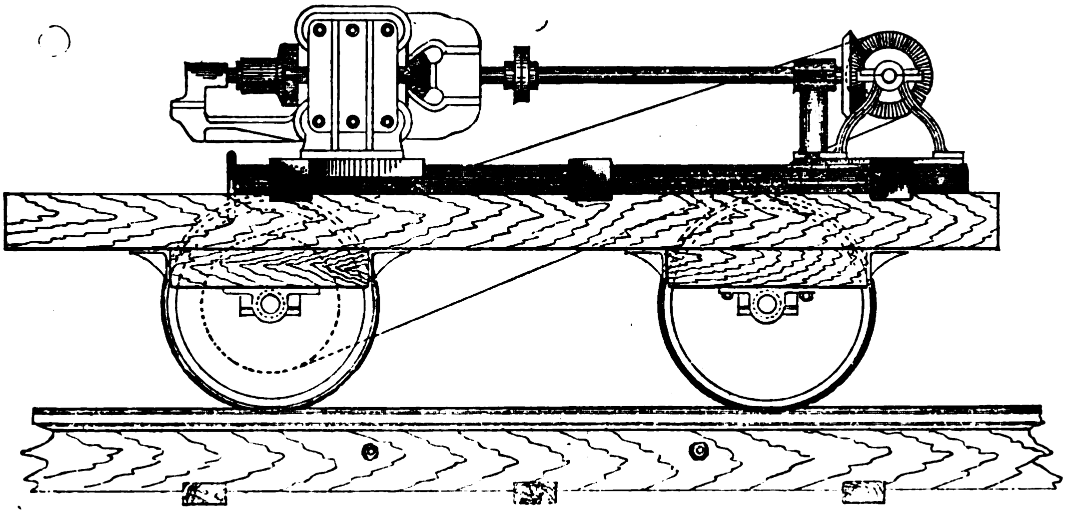

Fig. 3.

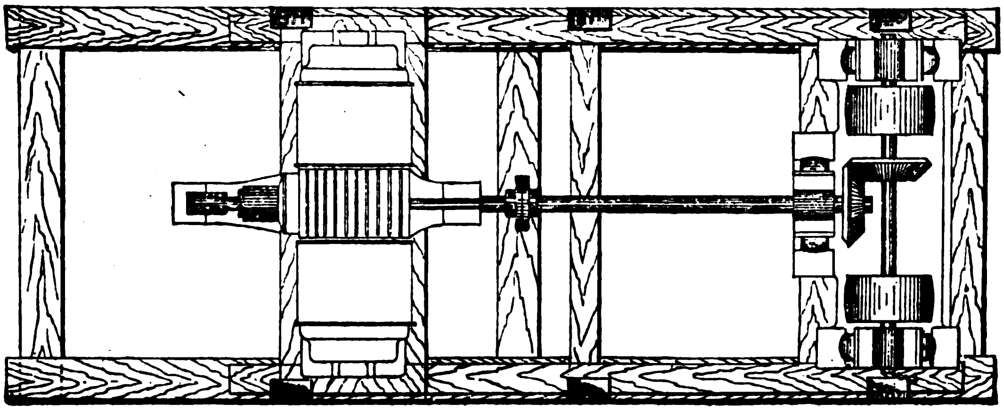

Fig. 4.

The track (Fig. 2) on which "The Judge" ran was laid in the gallery of the main building, extending around its margin, and curving sharply at either end on a radius of 56 feet. Its total length was 1,553 feet, or nearly one-third of a mile. This track, which was of three-foot gauge, was composed of three rails, in accordance with Mr. Field's method of conveying the current to the motor of the locomotive. The middle or central rail was connected with one pole of the stationary generator located below on the main floor at a distance of about fifty feet from the track. The two outside tracks were electrically connected together and with the other pole of the generator, as shown in the figure. This

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arrangement obviated the necessity of insulating the wheels on one side from those on the other, which is necessary when only two rails are used; as, for instance, in the railway now being laid between Bloomfield and Newark, in which case each rail is connected to one pole of the stationary generator.

The method of Mr. Field presents peculiar advantages, for it enables the electric locomotive to be adapted with little trouble to existing railroads, a result which would be practically unattainable by the other method, on account of the expense and the inconvenience of changing the wheels so as to make those of one side insulated from those of the other. Even the complication of construction of the wheels and axles which this method entails would be an objection, while the liability to derangements from short circuits would probably be much greater.

In order to secure a low resistance and proper connections between all the rails, a precaution made necessary by the low electromotive force of the generator, wires were laid under each rail. The inside rail was wired with No. 6 (B. & S.) bare copper wire and the outside rail with No. 8 iron wire. The central rail was also wired with No. 8 copper wire. A good contact was made with each rail by proper fastenings at the joints and also by laying the wire under the rails in the supporting plates, so that the weight of the rail rested upon it. These precautions practically reduced the resistance of the line to a value so small as to be inconsequential. It need scarcely be said that if the electromotive force of the current used had been higher these precautions would not have been required, and a simple connection of the rails together without wires would have sufficed. With an electromotive force of 300 volts, for instance, to produce the same current, the addition of ·25 ohm to the circuit resistance by the rails would not have produced a very marked lowering effect on the current delivered by the generator, but in this case it meant a reduction of one-third.

The internal construction of the locomotive will be readily understood from the accompanying figures (3, 4, 5, 6). Fig. 3 shows the locomotive in side elevation with its cab removed. Fig. 4 is a plan view of the same. These figures show the manner of transmitting the power from the armature of the motor to the driving wheels. The motor is placed crosswise upon the frame. Its armature shaft is coupled to an extension shaft, which is prolonged forward and transmits motion by means of bevel gearing to a countershaft carrying two pulleys. From these pulleys the power is transmitted by means of belts to the loose pulleys on the axle of the drivers. It will be noticed that this arrangement throws the greatest weight directly over the driving wheels. The gearing up of the armature extension-shaft to the counter-shaft was made so as to reduce the speed three times. The pulleys on the counter-shaft were 12 inches in diameter, the driven or loose pulleys on the axle of the drivers were 26 inches in diameter, and the car wheels, or drivers, were 30 inches in diameter. The maximum speed which this gearing would produce was about 12 miles per hour, but the weakness of the gallery upon which the track was laid made it necessary to run the locomotive at a lower speed. The average speed maintained was eight miles an hour, the motor revolving at the rate of about 750 turns.

Before proceeding further with the description it will be of interest and assistance to analyse briefly certain electrical conditions which rendered necessary the use of some of the mechanical devices which are yet to be described.

The two Weston machines used as generator and motor were of the "shunt wound" description, in which the current from the armature divides into two portions, one passing through the field magnet circuit and the other through the external circuit, the amount of current apportioned to each circuit being inversely proportioned to its resistance. When the resistance of the external circuit is great, a larger amount of current passes through the field magnet, and the magnetic field is made stronger. In this case the effect of opening the external circuit is precisely the same as if its resistance were increased to infinity; that is to say, all the current passes through the field magnets and the magnetic field attains its highest degree of power. On the other hand, when the resistance of the external circuit is reduced to almost nothing, the largest proportion of the current passes through the external circuit, leaving only a small portion to pass through the field magnets, and the magnetic field is very weak. Consequently, if we start a shunt generator with a closed external circuit of very low resistance, the small quantity of current induced in the armature by the residual magnetism of the magnetic field passes almost all into the external circuit, and the magnetism of the magnetic field fails to increase, so that the current developed remains small.

Now if, as in the case of the electric locomotive, the external circuit consists of a second machine to be worked as a motor, the resistance of which is very small, the generator will not develop current enough to start the motor. If, however, the leading wires add sufficient resistance to the external circuit to cause the diversion of an appreciable current into the derived or field magnet circuit of the generator, its magnetic field will increase in power and the current induced in the armature will consequently be greater in volume, and perhaps enough to start the motor. Consequently it would appear expedient to increase the external resistance at the time of starting the generator, so that its magnetic field may be charged sufficiently. When the motor begins to move it develops a counter electromotive force in the circuit which practically amounts to so much electrical resistance, and causes the further diversion of current into the magnetic field circuit. Thus, when once started, the counter electromotive force of the motor answered the purpose of resistance. It was found practically by Messrs. Rae and Healy in preliminary experiments with these two machines that the condition of best efficiency of the generator was realised when the motor had attained its maximum speed, and that the power developed was greater at that time. From this they inferred that the proper moment to put the load on the motor was when it had reached its greatest velocity.

The mechanism by means of which this was accomplished is quite ingenious and simple, as seen in Fig. 5, which represents a rear end elevation of the locomotive without the cab. The loose pulleys G G run on the axle of the drivers W W, as previously stated, motion being transmitted to them by belts from the pulleys of the countershaft, as already shown in Figs. 3 and 4. F F F′ F′ are cone friction pulleys fitting into the interior of the rim of the loose pulleys. These friction pulleys revolve with the shaft, being connected thereto by means of keys and keyways, which are loose, however, so that the friction pulleys can be free to slip lengthwise on the axle as they revolve. The hub of each friction wheel F_1 F_1 carries a collar E E, which is connected by arms D D to a lever B fulcrumed at C on a projection from another collar fitted around the shaft. The operation of this form of friction clutch will be readily understood. In the position shown the friction cones F F F_1 F_1 are removed from the pulleys, which are free to move loosely upon the axle. But upon moving the lever B to the right the friction cones are both moved outward from the centre, and caused to engage the inner surface of the pulleys, and thus the motion of the loose pulleys is communicated to the drivers W W.

As already stated, the central rail of the track formed one conductor and the two outside rails R R the other. The device for "picking up" the current was quite ingenious, and is also shown in Fig. 5. It consists of a kind of inverted vise firmly bolted to an arm, H H, projecting downward from the frame of the locomotive. The jaws N N of the vise are each perforated with three holes directed obliquely downward and inward, through which bundles of phosphor-bronze wire pass, being securely fastened and held by a screw, O. A spring, S, extending between the arms of the vise serves to bring the two brushes M M into close and sure electrical contact with the central rail P. The wire being stiff and firm, the contact is equally certain whether the locomotive is moving forward or backward.

An important feature of this electric locomotive is the means by which the speed may be regulated at pleasure. In the original electric locomotive of Edison, at Menlo Park, and, indeed, in all the electric motors ever constructed, so far as we are aware, the only means of regulating the speed

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is by allowing the clutch to slip partially, the motor being permitted to run constantly at its wonted speed.

In the Chicago electric locomotive there is a "throttle-valve" arrangement resembling that found in every American locomotive, and which answers the same function, namely, to control the amount of force put in action. The nature of the device is as simple as it is efficient, and consists simply in a lever (Fig. 6), by the motion of which the resistance of a suitable rheostat may be thrown in and out of the main circuit with the evident result of controlling the amount of current flowing therein. The lever is placed horizontally and can move over contact segments disposed in a circle. These segments are insulated from each other, but they are connected by coils of iron wires so as to make a certain resistance, and possessing sufficient area of section to remain cool. Thus, when the lever is in the position shown in the figures, there is no resistance included in the circuit. When the lever is moved forward to the next segment, the resistance added to the circuit is ·1 ohm. On moving to the next the resistance added is ·2 ohm, and so on, the amount of resistance included in circuit when the lever touches each segment being, in Fig. 6, indicated by the figures thereon. The rheostat comprised two Edison B lamps of 85 ohms each, so that the total resistance when the lever touched the last segment was 174 ohms. It will be readily understood that by means of this device the amount of current in the main circuit could be easily varied.

The high resistance necessary at starting to cause the magnetic field of the generator to magnetise itself was readily afforded by this rheostat on closing the circuit. Another interesting feature of the Chicago electric locomotive is the device by means of which the current is reversed at the motor when it is desired to make the locomotive move backward (Fig. 7). The lever J causes the wheel H H to turn on the armature shaft G. This wheel gears with two wheels, E F, to which are fastened arms, C C, D D. These arms carry brush-holders and brushes, A_1 A_2 B_1 B_2. The function of the device is simply to change the relative direction of the current through the armature of the motor. In the position shown in the figure the positive brush B_2 touches the commutator at the left-hand side, while the negative brush A_2 touches it at the right-hand side. On moving the lever J as far as R the brushes A_2 B_2 leave contact. On moving the lever still further the brushes A B now come in contact with the commutator of the motor, so that the positive brush B_1 touches the right-hand side of the commutator and the negative brush A the left-hand side, instead of the opposite. The result is necessarily a reversal of the direction of rotation of the armature of the motor.

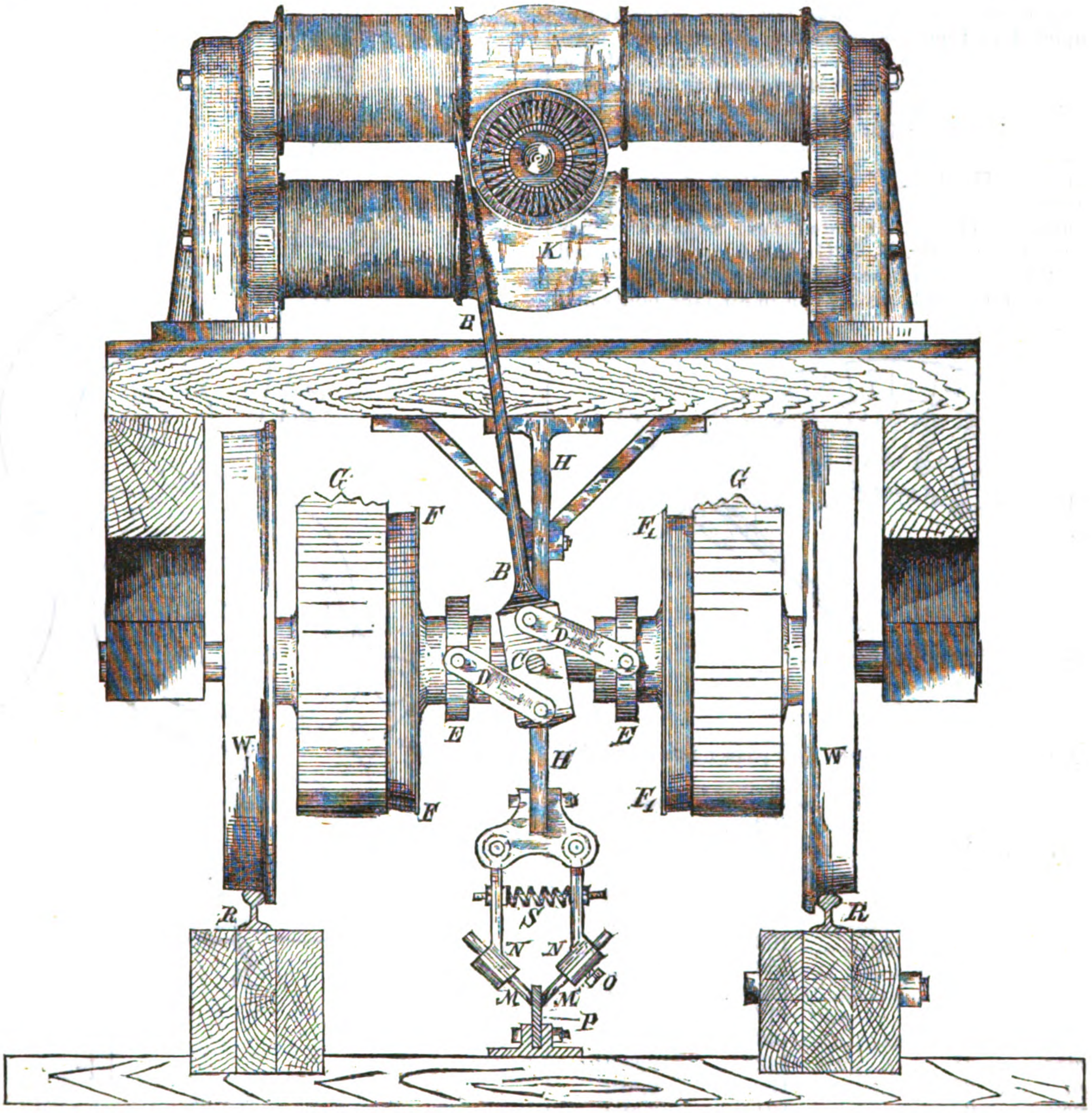

Fig. 5.

In this condition the motor is out of the circuit and receives no current. This is just the same as when the reversing lever of a steam locomotive is moved half way, thus cutting off the steam entirely by preventing the motion of the slide-valve.

The locomotive was also provided with an electric bell.

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This bell had a resistance of 350 ohms, and was rung by a switch which placed it in parallel circuit with the motor. Its high resistance prevented the diversion of the current from the motor in any appreciable quantity.

The locomotive was 12ft. long and 5ft. wide. Its total weight was about 3 tons. It was intended to be run with two passenger cars, but it was found upon inspection that the gallery was too weak to stand the strain. Even after having been strengthened, it was not deemed expedient to exceed the speed of nine miles an hour. The work of construction was done by the Excelsior Iron Works of Chicago, and the promptness and accuracy which characterised it are very creditable to the establishment.

The Chicago electric railway was the first constructed in this country for business purposes, and, considering the short lease of active life which was left to it after it was finally completed and put in operation, its success is most surprising. Owing to delay in receipt of the report of the engineer entrusted with the task of strengthening the gallery, the road was not permitted to operate for business until June 9, but experimental trips of the electrical locomotive were made daily from June 2.

Upon June 5 "The Judge" and its attached car loaded with 16 passengers (consisting of commissioners of the exposition and friends, all of whom were required to pay fare) was started by Mr. J. M'Gregor Adams and moved around the track. The railway was opened for business on June 9 and closed June 23, having run in all 118¾ hours and 446·24 miles.

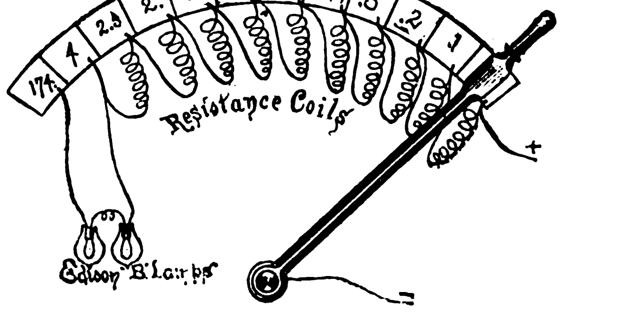

FIG. 6.

The daily report of trips made and passengers carried is as follows:—

	Trips.	Passengers.
Saturday, June 9	72	1,553
Monday, „ 11	66	985
Tuesday, „ 12	88	1,316
Wednesday, „ 13	99	1,552
Thursday, „ 14	109	1,372
Friday, „ 15	108	1,567
Saturday, „ 16	158	2,873
Monday, „ 18	115	1,654
Tuesday, „ 19	117	2,154
Wednesday, „ 20	148	2,484
Thursday, „ 21	142	2,829
Friday, „ 22	172	2,886
Saturday, „ 23	194	3,580
Totals	1,588	26,805

The success of the enterprise is due largely to the patronising efforts of Mr. J. McGregor Adams, one of the commissioners of the exposition, who placed every facility at the disposal of the Electric Railway Company, and rendered every assistance in completing the arrangements.

"The Judge" has been sent to the Louisville Exposition, where an electric railway is being completed to be in operation during the continuance of the exposition just opened at that place. Mr. Adams is also interested in this new venture, and Mr. Frank B. Rae will be the electrician in charge, same as at Chicago.

We regret that the uninterrupted operation of the electric railway during the last two weeks of the exposition precluded the possibility of making any measurements from which a definite idea of efficiency or of the cost of maintenance could be formed. We hope that better opportunities will present themselves at Louisville, and that the electrician in charge will not fail to satisfy the curiosity of the electrical world on this point.

The Electric Railway Company of the United States, as stated above, has control of the patents of Messrs. Field and Edison. The priority of invention of the former has been established in the Patent Office, and he has secured patents which virtually cover the fundamental principles and requirements of the art. The company is completing its preparations and will soon begin its work of development. A labora-

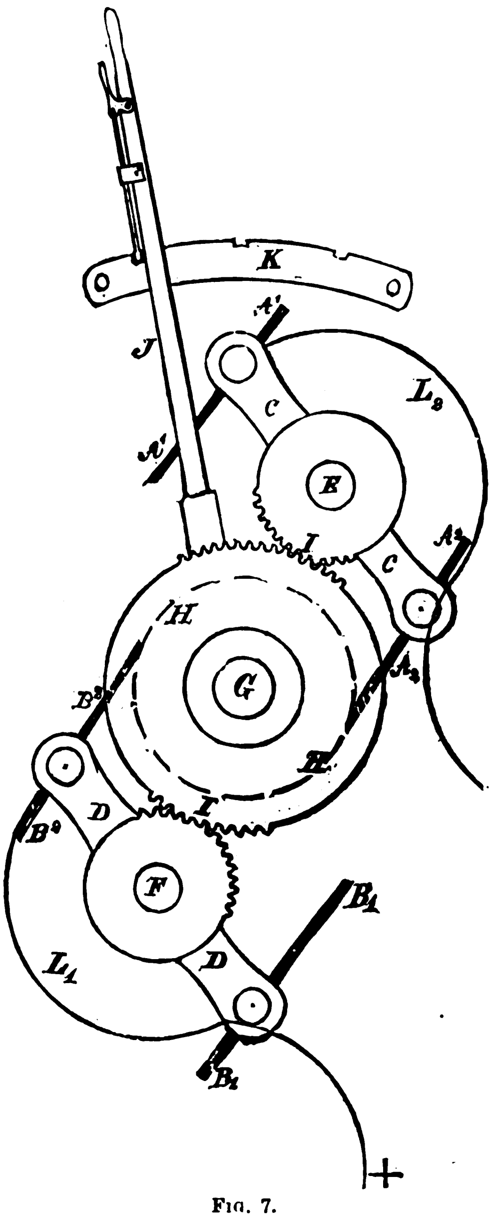

FIG. 7.

tory on a large scale will be established to facilitate the study of the best methods of adapting the means to the ends desired, and experiments will also be tried on a working scale on various railway lines.

THE WIRE QUESTION IN CHICAGO.—The latest development of the vexed question of overhead wires in Chicago has been the arrest of workmen who were stringing wires for electric lighting purposes by the Fire Alarm Telegraph Department of that city. It is stated by the Chicago papers, in commenting on the matter, that every electric light wire, with one exception, a wire from the Sherman House to the Olympic Theatre, is strung in violation of city ordinances.

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CORRESPONDENCE.

SINGLING OUT A STRAND OF MULTIPLE CABLE.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: If you will kindly make public the undermentioned method of singling out a strand of multiple cable it might interest some of your readers.

Supposing we have a mile of 20 conductor multiple cable and one particular strand in its centre is required. Connect both ends of conductor to key and battery (two or three cells), get a telephone receiver and a small coil of fine wire, about 150 ohms resistance, then divide the strands of the cable a few inches apart, and place the coil on the strands. When the strand is singled out to which the battery is connected, if an assistant makes and breaks contact the click caused by the make and break will be distinctly heard. I think this method would also be very useful in finding any circuit, thereby saving pricking the core.

I should be glad to know whether this plan has ever been tried. I have never heard of it, but while testing cable it occurred to me that it might be successful, and I have lately proved it to be eminently so.

All to whom I have mentioned the method say that they have never heard of it before.—Yours, &c.,

August 20, 1883. WALTER ROWBOTHAM.

MEDICAL ELECTRICITY.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I think the fact that toothache can be instantly stopped by the application of electricity in the following simple manner is not so generally known as it deserves to be:—With a small piece of zinc and a bit of silver (any silver coin will do), the zinc placed on one side of the afflicted gum, and the silver on the other, by bringing the edges together, the small current of electricity generated immediately and painlessly stops the toothache.—Yours, &c.,

22nd August, 1883. P. NELL.

[As there is plenty of toothache about, and no great lack of silver and zinc, we may confidently expect that some of our readers will test the above suggestion, and let us know the result.—[ED. *E.*]

CARBON BLOCKS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Can any of your correspondents tell me how to prepare ground carbon so that I can form it into blocks of any shape?—Yours, &c., J. J. CARR.

North Shields, Aug. 15, 1883.

ELECTRO-MOTORS AND THEIR GOVERNMENT.*

BY PROFESSORS W. E. AYRTON, F.R.S., AND JOHN PERRY, M.E.

(CONTINUED FROM PAGE 334.)

BEST RELATIVE SIZES OF THE ARMATURE AND FIELD-MAGNET IN A DYNAMO AND IN A MOTOR.

Having arrived at the complete expression for the electromotive force in a dynamo or in a motor, we can now determine the proper relative proportions to give to the armature and field-magnet in each type of machine.

Let C and C′ be the currents passing round the field-magnet and armature respectively; then, since W and W′ are the numbers of convolutions on the field-magnet and armature,

$$F : A :: \frac{W C}{1 + s C} : \frac{W' C'}{1 + s' C'},$$

or if the iron cores of both the field-magnet and of the armature are far from saturation, then, approximately,

$$F : A :: W C : W' C'.$$

On referring back to the complete expression for the electromotive force in terms of n, ϕ, and γ, we see that we may roughly state the second part as $W' A \sin. 2(\phi + \frac{1}{2}\gamma)$. Hence, for a rough generalisation, we may say that the electromotive force equals

$$n f(n) W' (F \cos. \phi \mp A \sin. 2\phi),$$

and using the last proportion, the electromotive force E is proportional to

$$n f(n) W' (W C \cos. \phi \mp W' C' \sin. 2\phi),$$

or the electrical power of the motor

$$C' E \propto C' n f(n) W' (W C \cos. \phi \mp W' C' \sin. 2\phi).$$

Now, let us assume that the field-magnet and armature form together one continuous magnetic circuit, such as would be produced by an anchor ring all wound with coils of wire forming one or more distinct circuits, and traversed by currents all flowing in the same direction; then, if all parts of this magnetic circuit be equally heated, the magnetic moment of any part will be simply proportional to its length, whatever be the number of convolutions on this particular part or the currents flowing through them. Hence, if the field-magnet and armature in a dynamo or motor be equally heated by the currents passing round them, W C and W′ C′ will be simply proportional to the lengths of the two portions into which we divide this closed magnetic circuit, and which are called respectively field-magnet and armature. If, therefore, L and l be the lengths of the magnetic circuit given up to the field-magnet and to the armature respectively, $L + l =$ constant, say, K, for a machine of a given type and weight. And since, as we have shown,

$$C' E \propto n f(n) (L l \cos. \phi \mp l^2 \sin. 2\phi),$$

we have to determine L, l, and ϕ, so that the latter expression may become as large as possible.

First, let us take the case of the negative sign, and let ϕ be positive (that is, the machine is a dynamo with a forward lead or a lead in the direction of rotation), then it will be found that the expression has a maximum for a very small value of l. For example, if ϕ is 30°, then the maximum is obtained when l equals $\frac{K}{4}$. If ϕ is 45°, then l equal to $\frac{7}{34}$ K makes the expression a maximum, &c. In other words, in a dynamo machine in which the brushes have, as is usually the case, a forward lead, the armature should be very small compared with the field-magnet, and should be the smaller the greater is the lead of the brushes.

Second, let us take the case of the positive sign, and let ϕ be positive, which corresponds with the case of a motor having a forward lead, then it will be found that, except for very small values of ϕ, the expression for the electromotive force has no maximum in the mathematical sense of the expression, but, instead, that as l increases the electromotive force continuously increases; hence, for any value of ϕ, such as 20°, l should be made as large as possible, to make the electromotive force as large as possible. In a motor, then, the armature should be by far the largest part of the machine.

If we assume merely that the weight of the machine is a constant, which is roughly the same thing as saying that the sum of the volumes of the field-magnet and armature is a constant, and if we assume that in making the field-magnet or armature larger or smaller in volume we increase the dimensions in all directions, so that the shorter part is thick and the long part thin, then we shall have some such relation as $A^2 + F^2 =$ a constant, say, K^2, if the volumes of the two component parts of the machine are considered as being proportional to the squares of their greatest magnetic strengths.

If, now, we take the case of a motor, that is, use the positive sign in the expression for the electromotive force, then we find that a maximum is obtained when

$$F^2 = \tfrac{1}{10} K^2,$$
$$A^2 = \tfrac{9}{10} K^2,$$
$$\text{and } \sin. \phi = \tfrac{2}{3},$$
$$\text{or } \phi = 42°, \text{ approximately.}$$

Hence the armature must have 90 per cent. of the whole weight, and the field-magnets only 10 per cent.

On the other hand, if for the dynamo we take the same value of ϕ with the negative sign, then we find that the maximum electromotive force is obtained when it is the armature that has only about 10 per cent. of the whole weight, and the field-magnet 90.

We have every reason to believe, therefore, that an investigation concerning these relative sizes in a motor made to any design such as we can at present imagine, if soft iron is used in the field-magnet, must have the result that the armature part ought to form a much greater part of the whole weight than the field-magnet part, whereas in a dynamo machine it is the armature to which the very small weight is given.

When we consider, however, that the apparent resistance of a motor or dynamo due to self-induction is in proportion to the

* A Paper read before the Society of Telegraph Engineers, May 10, 1883.

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armature strength, we find that it is necessary to make the armature less in importance than might be assumed from the above investigation, and our own practical rule at present in the motors shown to the meeting consists in making the field-magnet about one quarter the weight of the armature.

It must be remembered that it is not merely a condition for greatest steady power of a motor or dynamo which we have been looking for, but also a condition for greatest efficiency with a greatest steady power, because of two machines of the same power, when heated up to less than a destructive temperature, the larger will waste most power.

Now an armature, from its shape, is necessarily a weak magnet, while the field-magnet, from its shape, is a strong one; hence in our motors we have reversed the usual condition of things, and made the armature large and the field-magnet small, and from this we have been led, as will be seen from the accompanying figure (No. 21), to make the armature stationary and surrounding the field-magnet, instead of, as is usual, the field-magnet surrounding the armature.

these poles, and the brushes, which, be it remembered, are carried by the field-magnet, are so set that the magnetic poles in the armature are always a little way in front of the poles of the field-magnet. The latter, therefore, are perpetually running after the former, but never catching them.

We have spoken about the lead of the brushes, which we have seen is of great practical importance, since the amount of lead decides not merely which way the motor revolves, or whether it revolves at all, but also whether the fields due to the field-magnet and armature are added to one another or subtracted from one another in producing the resultant field. Although the fact that the direction of rotation could be reversed by a sufficient change in the lead was well known, the importance of varying the lead in motors for different speeds appears to be little attended to, since, as a rule, it is impossible in motors, from their construction, to make small changes in the lead. In our motors, on the other hand, the flat brush-holder can be revolved forwards or backwards by hand through any angle, so that any lead forwards or backwards can be given to the brushes for each speed, and in our

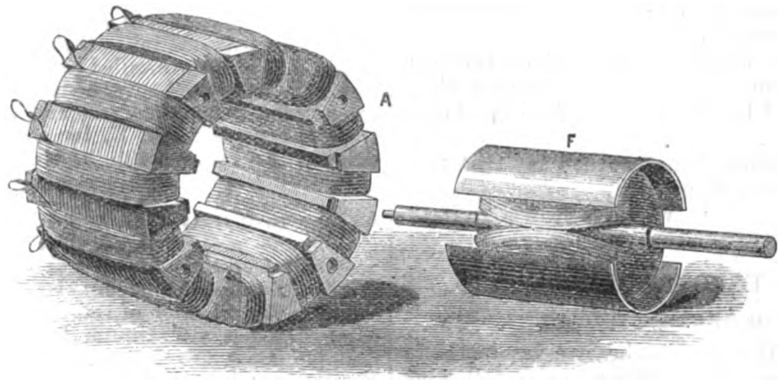

FIG 21.

Our small field-magnet, F, then carries the brushes and revolves inside the stationary armature, A, the coils of which, as is seen in Figs. 1, 2, 3, and 24, are joined to the stationary commutator, C C, which on some of our motors we make flat, to save both space and expense, while in others it is cylindrical, as this

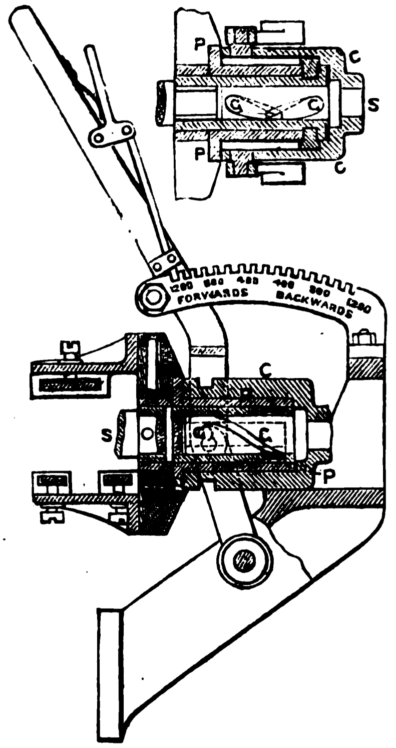

FIG. 22.

gives rise to less friction than the flat commutator. Wherever the brushes, B, happen to be at any particular moment, their two opposite magnetic poles are produced on the armature, or rather the poles are produced at two points in the armature, a little behind the brushes. As the brushes run round and round, so do

larger motors, one of which is shown in Fig. 3, the lead can be made anything we like simply by moving a handle, H, such as a locomotive engine-driver is accustomed to use for acting on the link-motion of his engine. Push the handle, shown enlarged in Figs. 22 and 23, forwards, and the motor revolves rapidly in one direction; pull it backwards, and it revolves as rapidly in the other direction. Push it not so far forwards, and it does not revolve so fast in the first direction; pull it not so far backwards, and it does not revolve so fast backwards. In fact, by moving the handle forwards or backwards, any speed in either direction is obtainable. The action of our "lead adjuster" is as follows:— Attached to the rotating field-magnet is the spindle, S S, which is itself attached to, and rotates with, the outer collar, C C. On

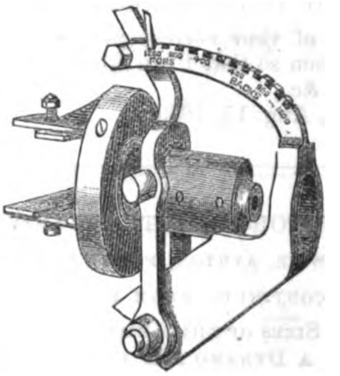

FIG. 23.

pushing the handle forwards or backwards, this collar is moved along the spindle, and the effect of this is to cause a pin to move along the groove, G G, and so cause the inner collar, P P, which usually rotates along with C C and the field-magnet to move a little forwards or backwards relatively to C C. Now it is the collar, P P, which is screwed to the brush-holder, hence we are able, even when the motor is running, to shift the brushes relatively to the field-magnet together with which they are rotating, and consequently to give any lead forwards or backwards we desire. In other cases we alter the lead by means of a wheel, W, and screw, as seen in Fig. 24, and so get very easily a very accurate adjustment. A table of speeds can be engraved, showing the position the handle should be in for 500 revolutions a minute, or 700 revolutions a minute, &c.

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Effect of Lead on the Brushes on Sparking.

We have already explained that one cause for the sparking at the brushes arises from self-induction, but there will be another cause, arising from an electromotive force existing in the coil short-circuited at a brush, if such a coil be cutting lines of force owing to the brush not being at a neutral part of the resultant field. Hence the importance of placing the brushes at the neutral part of the resultant field. In a dynamo a forward lead will do this, as shown in the following figure (No. 25), where S N represents the magnetic axis of the field in the armature, produced by the current flowing round the field-magnet, and modified by all the iron in the machine; N′ S′ the magnetic axis of the field produced in the armature by the current flowing round the armature, and modified by all the iron in the machine; and *s n* the axis of the resultant magnetic field, which is at right angles to B B, the line of the brushes.

If the machine is a motor with a forward lead, then the polarity af N′ S′, due to the armature coils, must be reversed, and we have the arrangement shown in Fig. 26. The axis of the resultant fields is now not perpendicular to the line of the brushes, and so there must be some sparking; but the two are more perpendicular than in Fig. 27, where the direction of rotation is reversed, and which would correspond with a dynamo having a backward lead. Consequently, while in a dynamo a back lead of the brushes, corresponding with the two fields strengthening one another, would be to some extent balanced by excessive sparking, this is not so much the case in a motor with a forward lead of the brushes, since the twist in the field, due to the rotation, assists the perpendicularity of magnetic axes in a motor, while it diminishes it in a dynamo. And as a proof that putting the brushes with a backward lead in a motor, so as to prevent all sparking, is really detrimental to the power and efficiency of the motor, we append the following results of experiments made by us on this subject, using a motor weighing thirty pounds, consisting of a Gramme ring rotating inside a Siemens field-magnet:—

Lead.	Remarks.	Revolutions per minute.	Current in amperes.	Potential difference at terminals in volts.	Load on dynamometer in lbs.	Horse-power given in.	Horse-power given out.	Efficiency per cent.
−45°	Very little sparking at the brushes	3,162	11·2	35·6	1·1	0·535	0·116	21·6
0°	Much sparking at the brushes	3,045	9	41·2	,,	0·499	0·111	22·3
−20°	Less sparking at the brushes	3,130	10·1	42·5	,,	0·576	0·115	19·9
0°	Much sparking at the brushes	3,248	8·2	42·7	,,	0·468	0·119	25·4
−20°	Less sparking at the brushes	3,405	9·4	42·7	,,	0·538	0·124	23·1
0°	Sparking partly due to the brushes requiring trimming.*	3,147	9·0	42·9	,,	0·519	0·115	22·2
−30°	Little sparking at the brushes	3,228	9·7	42·5	,,	0·578	0·118	20·4
0°	Much more sparking at the brushes	3,181	8·2	42·5	,,	0·469	0 16	24·8

* As the brushes were observed to be not making as good contact as possible with the commutator they were here taken off and trimmed, and the experiments repeated.

A negative lead means a lead in the direction of the lead ordinarily given to the brushes in a motor, or against the direction of rotation.

From an examination of the potential difference at the terminals with the current sent through the motor in each case, it will be seen that for a lead of 0° there is the highest back electromotive force. Further, from an examination of the table of efficiencies it is seen that a lead of 0° gives a higher efficiency than a negative lead.

It has already been pointed out that the condition of non-sparking at the brushes, apart from self-induction, is the same as the condition that the number of lines of force cutting a coil should not alter as the coil passes a brush; and, referring to Fig. 18, we see that this is the same as saying that the brush should be at the top of a crest or at the bottom of a wave in the curve for the resultant number of lines of force cutting a coil. In the case of the curve D, corresponding with a dynamo with a forward lead, we see that this condition is fulfilled with considerable accuracy, and also that it is approximately fulfilled in the case of the curve M, corresponding with a motor with a forward lead.

In Fig. 27 we have already seen roughly what would happen if we employed a backward lead in a dynamo. Let us now, with the aid of the curves shown in Fig. 19, consider how far the employment of the sum of the strengths of the fields due respectively to the armature and field-magnet, instead of the difference, which is all that is ordinarily made use of, would be beneficial. Let us take $\phi + \gamma$ equal to $-22\frac{1}{2}°$, and ϕ to about $-35°$; that is to say, let there be a back lead of 35°. The number of lines of force then cutting a coil at a brush, due to the armature field as affected by the rotation, as well as by the distorting action of

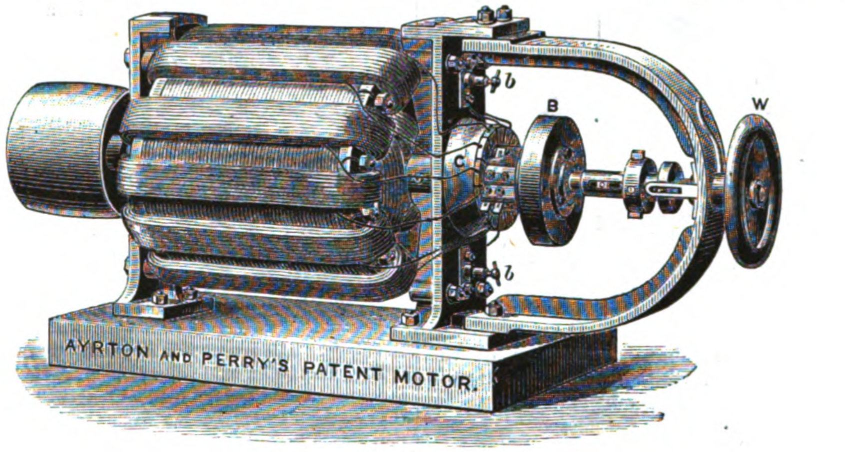

Fig. 24.

the field-magnet, will be represented by something like J K in Fig. 19, corresponding with an angular distance of $-35°$ in the curve corresponding with $\phi + \gamma$ equal to $22\frac{1}{2}°$. Now J K is very small, and, further, the number of lines of force due to the field-

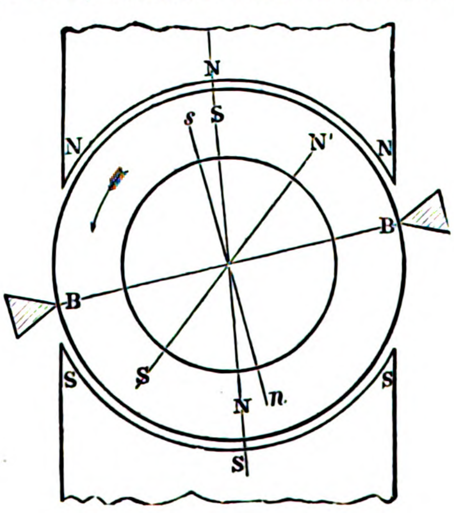

Fig. 25.

magnet cutting the coil when at a brush at $-35°$, corresponding with J K, Fig. 20, is also much smaller than its value, B K, at the brush when it has a forward lead. Hence the sum of these two sets of lines of force for a back lead may not be so large,

compared with the corresponding differences when the brush has a forward lead, as to counterbalance the injurious effect of sparking.

Determination of the Power and Efficiency of Motor Absorption Dynamometers.

The power in watts given to a motor, or indeed to any circuit to which electric energy is being supplied, is equal to the current, C, in amperes passing through the circuit multiplied into the potential difference, V, in volts at the terminals. A portion, $C^2 R$, of the power so furnished to the motor is wasted in heating the motor, due partly to the statical resistance of the motor, R_0, or resistance of the motor at rest, and partly to the increase in the

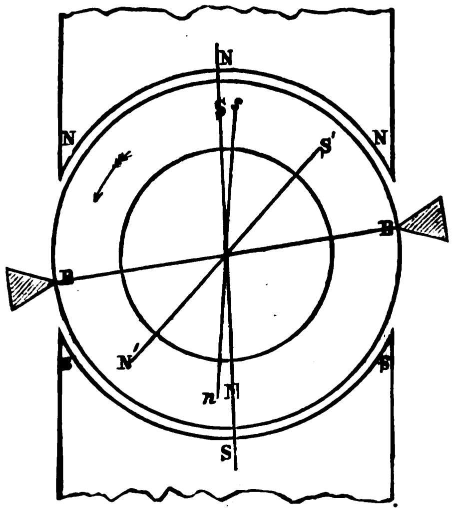

Fig. 26.

resistance, $n\ p$, already referred to, and which is produced by self-induction. The remainder of C V, which is equal to C v where v is the back electromotive force in volts produced by the motion, is converted immediately into mechanical energy of rotation, but not necessarily into useful energy, since a portion of the power the motor produces is spent in overcoming the mechanical friction at the bearings and the mechanical friction of the brushes rubbing on the commutator, while another portion is spent in overcoming air friction and what may be called magnetic

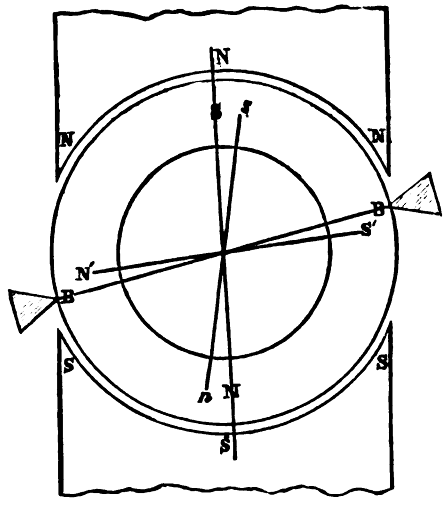

Fig. 27.

friction—that is, the resistance arising from the generation of Foucault currents in all pieces of metal, the number of lines of force cutting which is alternately increased and diminished as the movable part of the motor rotates; and it is only a third portion of the power the motor develops which is usefully given out, this latter, in watts, being equal to the torque, T, multiplied by n, the number of revolutions per minute, where T therefore stands for the moment of the twisting couple exerted by the moment in pound feet divided by 44·25.

The following table shows graphically the way in which the power supplied to a motor is used up :—

C V {
- $C^2 R$ {
  1. $C^2 R_0$.
  2. $C^2\ n\ p$.
- C v {
  3. Power spent in overcoming the friction at the bearings and the friction of the brushes against the commutator.
  4. Power spent in overcoming magnetic friction arising from the creation of Foucault currents and in overcoming the friction of the air.
  5. Power usefully given out by the motor and equal to T n.

The real power of the motor is simply of course T n, and the efficiency only $\frac{T\ n}{C\ V}$. In theoretical calculations not unfrequently 4 is totally neglected; indeed, in the published calculation of the efficiency of a well-known motor that recently was brought to our notice, 2, 3, and 4 were neglected, and the efficiency was said to be 90 per cent. Indeed, $C^2\ n\ p$ is almost invariably neglected, so that only $C^2 R_0$ is assumed to be the waste of energy from heating, whereas it must necessarily be $C^2 (R_0 + n\ p)$, even if all masses of metal in which Foucault currents might be generated were so electrically subdivided as to diminish the generation of such currents to a very small amount.

To measure, then, the power and efficiency of a motor, the important things to observe are C, V, T, and n. T may be measured with some form of absorption dynamometer, of which we have found the compensating forms devised by Professor James Thomson, by M. Carpentier, and by M. Raffard very convenient, while the older Prony brake can be made to give fairly good results for a short time if a constant stream of water be allowed to flow over it.

(TO BE CONTINUED.)

PILSEN, JOEL, AND GENERAL ELECTRIC LIGHT COMPANY (LIMITED).

The second ordinary general meeting of shareholders was held on Wednesday at the Cannon-street Hotel, Sir Rawson W. Rawson, K.C.M.G., C.B., the chairman of the Company, presiding.

The notice calling the meeting was read by Mr. E. T. Gregory, the secretary. The report and accounts were taken as read.

The Chairman said : Gentlemen, it being your wish that the report and accounts should not be read at length, I think you will all agree with me that on such an oppressive day as this you will be very little disposed to listen to a long speech, and I certainly feel very little qualified to make one; nor do I think that the report and accounts which have been submitted to you, which are so full and explicit, need much detailed or lengthened observation on my part. There are, however, two or three things which I desire specially to bring to your notice, which will not occupy much of your time. The first and most material, of course, is as to the necessity for the call that the directors are making upon their shareholders. You will remember that this Company was formed under very different circumstances from those in which it was brought into operation. When the prospectus was issued the directors had an expectation, amounting to a belief, that they would derive from the sale of the concession of these patents, even in the United Kingdom and in the colonies, an amount of capital which would enable them to carry on their manufacture and other operations without pressing upon their shareholders in any way. They therefore, as I mentioned when I last had the honour of meeting you, instead of calling up £3 per share upon allotment, reduced the amount to £2, and they believed, and they had the expectation then, that whenever the Company was called upon to supply electricity in a town or district they could derive that aid from the auxilliary companies which would suffice to carry on their operations. However, as you know well, circumstances changed almost at the moment of the birth of this Company. The expectation of an early sale of concessions was deferred. There was a reaction of public feeling with regard not only to electric lighting companies, but with respect to electric lighting generally; and the action of Parliament, wise as it may have been, and wise as I believe it has been, in the interests of the public, was a necessary check upon the operations of the several electric lighting companies. We have struggled during the year against all the difficulties which we and the other electric lighting companies have experienced. We proceeded with the confidence that we possessed, in the patents of our Pilson and Gatehouse lamps, an article which would stand the brunt of competition, and which would survive whilst others less effective fell to the ground; therefore we had no hesitation in prosecuting our enterprise. We did not start originally with the idea of being mainly a manufacturing company; and therefore our capital was fixed at an amount less adapted to extensive manufacturing purposes than to the possibility of deriving from auxiliary companies the means of developing our patents. They would have found the capital and we should have supplied the machines and the lamps. That expectation, however, has been postponed. We do not abandon the hope that when the desire to possess electric lighting (which is daily increasing

shall have become general, when our colonies shall have had the opportunity of testing the value of the several lights in the United Kingdom, that we shall find a large market for our property in the colonies, and a demand for concessions which we already have in negotiation with the expectation of their being eventually carried out; and we have the expectation that our property will then realise what we at first hoped, but which up to the present has been deferred. We have carried on under great difficulties during, the past year, but we think we stand in a position as good as any of the younger companies formed for the same purpose as ourselves. We cannot boast of the position of the companies which are two or three years our seniors, who embarked a large capital in their enterprise, who had the start of us, and who had possession of the field before we came into existence. That has been necessarily one of our difficulties—that during the past year Great Britain had been covered by the auxiliary branches of the companies existing before we were created; and a subsequent difficulty has been that we have had to compete with companies who, under peculiar circumstances, to which I need not refer, have pressed the sale and use of their dynamos and lamps on terms with which neither this Company nor any other could profitably compete. We have also had the difficulty of a necessary delay in improving the quality of our several forms of manufacture, not that it was necessary to improve, but that we could improve, and therefore had been aiming at improvements, and are, with success. Every one of our lamps respectively is of better manufacture, our dynamos are more efficient, than those of the original form. We have also been occupied, as you are aware, and as our report tells you—we have been occupied, more particularly during the last three or four months, in completing new forms of our manufactures. A cheaper arc lamp was not only a desideratum, but an absolute necessity. For certain purposes the present arc lamp, excellent as it is, is considered too dear, and we have had it in view to construct a lamp of equal efficiency, but in a different form, and at a cheaper cost, and in that we have been entirely successful. We have also had the difficulty during the past year of perfecting an incandescent lamp. As the prospectus announced to our shareholders, the Gatehouse incandescent lamp was not in a perfect form when we bought the patent, and since then the manufacture of incandescent lamps has so advanced, and has been so much improved, and every one of the companies have so greatly improved their incandescent lamps, that if it had been perfected at that time we should have had to improve it to carry on a fair competition with our rivals. We believe now we have attained that object. We believe the incandescent lamp, as regards the economy of making, and as regards the probable duration of its life, will compete with any of the most favoured forms of incandescent lamps in the market [hear, hear]. Another great object has been to complete our incandescent dynamo machine, which was excellent for the arc light, but was not adapted to the incandescent light. We have had, therefore, so to adapt it, and we have succeeded in adapting it, so we are now in a position, which we have not been in up to the present time, of supplying not only the best arc lamp—we believe the best arc lamp in the market—but we can now supply an incandescent lamp as good as any other, and an incandescent dynamo which we did not possess up to the present time. Therefore one year, although it has not been spent in producing much, has been spent in preparing the means of a profitable exploitation of the Company's affairs during the present and future years [hear, hear]. Upon these grounds, which have been already stated in the report which has been in your hands for several days, and which you have had an opportunity of examining—upon these grounds we believe we are justified in saying that the prospects of the Company are encouraging, and that we have laid the foundation of a profitable business [cheers]. Those who are familiar with the manufacture of electrical apparatus, who know the enormous difference between the construction of an ordinary piece of mechanism and an electrical machine, who know that although you may have a perfect mechanical construction of the parts, yet that the subtleties of electricity being invisible and most capricious, as far as we yet know are elements which form a very important part in the successful construction of the machine, will well understand that there must be delay and expense in the successful manufacture of a new form of electrical apparatus. To you, therefore, it will not be a matter of surprise that there has been delay and expense in perfecting our several forms of manufacture, and to those who have watched the proceedings of the companies, and have studied their reports and their accounts, it will be apparent that the amount of time and the amount of money expended by this Company is not to be compared with the amount of money and the time that has been expended by other companies in attaining the same results which we have now reached [hear, hear]. For instance, whilst in the Lane-Fox incandescent light the cost of perfecting that may be measured by tens of thousands, whilst it has taken years of thought and labour to produce the Edison incandescent machine, the results we have attained — which we confidently believe we have attained — during our first year of existence, will, I think, deserve the congratulation of our shareholders [hear, hear]. The sum expended has been comparatively small, the time has been equally short. That is sufficient with regard to the past; the report will speak for itself as regards the future. There is one point which I cannot pass over, which is the costs incurred by the Company with regard to provisional orders. The only order with which we persevered, for reasons which the report explains, was passed without opposition, both by the Board of Trade and in the Houses of Parliament, and we hope soon will become an Act. The other two orders, although we did not persevere in them, it was simply because the local authorities were desirous of obtaining provisional orders for themselves, and were quite prepared to give us the orders which we had applied for as soon as they possessed their own provisional orders. It is an advantage, therefore, for us to work with these boards and obtain their assistance, which we probably shall, both financially and morally; and therefore we consider it a success to stand in the position we do with regard to that. Before concluding, there is one matter which I desire to bring to your notice, which is the attempts which have been made lately to injure the credit of the Company, and if possible to drive it into liquidation. These have, happily, been defeated, and I wish not to say anything which may excite any acrimonious feeling with regard to the past. I would rather that those who attempted to injure us, finding they failed, should work with us, so that we might all work together for the advantage and success of the Company; but I must say, firstly, with regard to this, that it has been sufficiently exposed by the publicity given to the circumstances under which the action in all its points has been repudiated, and with respect to the latter it has been sufficiently condemned by the dismissal of the petition with costs. Unfortunately, as the directors consider, they had no opportunity of challenging and disproving the allegations of the affidavits made in support of the petition. The petition was withdrawn at the last moment, although the afternoon previous an additional affidavit was brought forward by the petitioners; therefore, to the last moment they were prepared to defend their position, but at the moment of the case coming on they withdrew it, and the directors are sorry they had not the opportunity publicly of challenging and disproving the allegations of the petition, and showing the unjustifiable character of it. Having had that opportunity, they have deemed it, in the interests of the Company, desirable to obtain the opinion of the eminent counsel who conducted their case, Mr. Napier Higgins, as to the character of the allegations brought forward in the petition, and that eminent counsel has given his opinion that there was no justifiable ground whatever for it, that it was not a *bona fide* proceeding for the protection of the interests of the shareholders, and that it was intended as an attack upon the Company, and as such it is his opinion that an action would lie against the petitioners for the unwarrantable and unjustifiable attempt to injure the Company. This opinion is now under the consideration of the directors; and certainly, if it is necessary for us to defend the interests of the Company by bringing an action against these petitioners, or against any others who make a similar attempt upon equally unjustifiable and futile pretences, the directors will, in the interests of their shareholders, not fail to act, and prosecute to the end anybody making an attempt of that kind [hear, hear.] It has been satisfactory to the directors, and it doubtless must be satisfactory to the shareholders, to see the determination of the judges to protect public companies against such petitions. We may hope that the view taken by the judges, that the views of a minority not supported by facts, and not capable of proof, cannot and ought not to possess the ears of judges, and that they will not entertain attacks of this nature, but, as we have seen lately, will punish them by the dismissal of the petition, will have its due effect. You cannot wonder, gentlemen, that attempts of this kind have, during the last month or six weeks, seriously prejudiced the Company. Two contracts at least have been fatally delayed in consequence of these attempts, for naturally no parties will enter into a contract with a company which has a petition of this kind hanging over it. Therefore, it being of such consequence to the Company, the directors are determined to do their best to prevent the repetition of such an inconvenience [cheers]. I am happy to tell you that within the last three days a very important contract with an important department of Her Majesty's Government, which had been nearly completed before this petition was filed, and the completion of which was unavoidably held back until the decision of the Court was known, is now in the process of completion [cheers]. Other inquiries with regard to our lights, with the expectation of successful and valuable contracts, are rapidly coming into the Board, and so far good may come out of evil. The evil has attracted notice; the quality and excellence of the wares that the Company has to offer have attracted notice, which, perhaps, a number of expensive advertisements might not have succeeded in doing, and we hope that we may derive advantage from what has taken place; but it is too dangerous a matter to be allowed to be repeated if we can possibly prevent it. I hope that nothing of the kind may arise, and that next year will enable us to successfully develop the affairs of the Company. The directors have, during a year of great discouragement, of great difficulty, and of a most unfavourable season, transacted your affairs with a single eye to your interests. They are largely interested themselves in it, but they are not at all largely interested in remaining directors. Their sole interest is to prosecute the affairs of the Company with a view to your interests. They have avoided any extravagant enterprises, any extravagant purchases of patents, any expensive exhibitions or unremunerative exhibitions; they have not involved the Company in a single legal difficulty, they have not made a bad debt, and the Company now possesses a property which is capable of being developed with profitable results, and I trust that the shareholders present to-day, having studied the report and accounts rather than anything that I have had to say, will be prepared by the adoption of the report to testify their continued confidence in the honesty, industry, and care of their interests on the part of the directors. There is one point I really felt rather reluctant to refer to, because it affects the directors themselves. You may have seen in the accounts that the directors who have been in charge of your affairs now for fifteen months, and who are entitled to draw during the time fees to the extent of £1,100 odd, have drawn less than £120. The explanation of that is that when the funds of the Company in the month of April fell short the directors felt that they ought to economise in every way they could, and that until the affairs of the Company were more prosperous their remuneration should be deferred; and, therefore, with the exception of the comparatively small sum drawn by the chairman and one of the directors who act as a committee at the factory, the directors have not drawn their salaries, but have deferred them. It seems in the accounts that that item is not included in the liabilities, and therefore it is right that I should mention to you that, if the affairs of the Company flourish during the ensuing year, they are confident that you will not grudge the directors the amount which you originally awarded them in the Articles of Association. I now beg to propose that the directors' report and accounts as published be and are hereby received and adopted.

Major-General Hopkinson seconded the motion.

Mr. Morten thought that a larger value had been placed upon the stock and plant than they would realise if sold. He complained that there had been no installation on any sufficient scale for the London shareholders to see the merit of their light. He was afraid that they must say good bye to the money that had been spent. He thought the affairs of the Company should be put on a more business-like basis, and suggested that a board of consultation should be appointed.

Mr. Blaydon hoped that no money would be spent on installations which would not yield a profit. He thought their light was second to none, and what the chairman had said rather confirmed him in that view. He thought they had a capable board of directors, and did not believe in committees, who would only hamper their action.

Mr. Hopkins thought there was every disposition on the part of the shareholders to admit that the directors had done their utmost. Compared with other companies no doubt their expenses had been small, but still they were large, and the results obtained were not commensurate with the outlay. He was very pleased to hear that they had obtained the provi-

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sional order for lighting an important district in London, for he believed that it was principally in that direction that the directors would have to look for obtaining remunerative profits. They knew that the action of Parliament last year on the Electric Act prevented not only this Company, but all other companies from getting any powers, and he was very pleased that they had succeeded in getting an order for the important district of Holborn and New Oxford-street. With regard to the report he pointed out that there were thirteen months' expenses on the one side, and only six months' receipts on the other. He did not think that an undertaking of this kind could be carried on at a very rapid rate, particularly as they had to face so many competitors, all stirving to attain the same object. Like other proprietors who had spoken, he believed the light of this Company, if not the best, was as good as any light in existence, and that being so he did not see why the Board should not be able to carry their proceedings to a successful issue. With regard to a friendly committee, he did not see how that was possible. So long as they had a board of directors they must either have confidence in them or not. He believed the directors were all good men of business, but they must not expect too much of them at first. He was glad to hear what the chairman had said about the petitions to wind up, for he had had with other companies lately a similar kind of experience. He should not himself be inclined to be quite so merciful as the chairman, and he thought that gentlemen who sought to wreck public companies where those companies had any assets to divide were not entitled to any consideration at all. He hoped the directors would not show them any consideration; but as to prosecuting them there was a question whether they were worth powder and shot. With reference to the call, he heard one or two gentlemen express surprise that the directors should have made a call, but if they were to carry on and establish this business, and have a large amount of stock and plant, he could not see how the directors could help making a call. His surprise was that they had not been obliged to make a call a little sooner. With regard to the directors' fees, he thought that a company had sunk to a very low ebb when the only economy that could be suggested was that the directors should reduce their fees. If the directors did their duty they were entitled to their fees, and he was very sorry that they had deferred them.

Mr. SPRULES complained of the small returns made by the Company.

A SHAREHOLDER asked why the Company's light was not to be seen at the Fisheries Exhibition.

The CHAIRMAN replied that this Company was one of the first asked to send its lamps to the exhibition, but they were to do so without any remuneration, and in fact at a considerable cost. As the light had been exhibited at the Crystal Palace the directors did not think it worth while to incur this outlay. With regard to the management they were quite satisfied, and believed that more had been done in the previous six months than in any former period. With regard to Mr. Joel, he had ceased to be engineer of the factory, and was now their consulting engineer.

The suggestion for the appointment of a committee was not pressed, and the motion for the adoption of the report was put and carried unanimously.

The retiring auditors having been re-elected a vote of thanks to the chairman and directors terminated the proceedings.

LANCASHIRE AND CHESHIRE TELEPHONIC EXCHANGE COMPANY (LIMITED).

The second ordinary general meeting of the shareholders of the Lancashire and Cheshire Telephonic Exchange Company (Limited) was held on Monday last, at the office of the Company, Faulkner-street, Manchester. Mr. Charles Moseley, chairman of the Company, presided. In the annual report, which was taken as read, the directors stated that at the last annual meeting the hope was expressed that the coming twelve months would bring new business to the amount of £10,000. This estimate had been exceeded, and the gross increase was nearly £12,000. The total income (including orders not completed and for which payment had not been made) on the 30th June, the close of the financial year, was £54,498 3s. 8d., as compared with £42,817 17s. 11d. last year. The gross rentals applicable to the year's revenue (including the out districts) amounted to £45,544 12s. 2d., against £27,227 5s. last year. The total number of subscribers to the exchanges on June 30, 1882, was 1,740, and of private renters 472; this year to the same date the number of subscribers was 2,359, and of private renters 697. The amount standing to the credit of the profit and loss account was £15,203 4s. 6d., out of which the directors proposed to declare a dividend of 5 per cent, which would absorb £13,000, leaving a balance to be carried forward to next year of £2,203 4s. 6d.

The CHAIRMAN, in moving the adoption of the report and statement of accounts, said that they would observe from the balance-sheet that their income had increased from £42,817 to £54,498, leaving them a net profit of £15,203. Out of that gross income they had to carry forward £23,391, which was received in anticipated rentals, as against £15,590 last year. It might strike some shareholders as singular that with so largely an increased income they had not a larger surplus of profit to divide, but it must be remembered that the balance of last year, which enabled them to pay a 5 per cent. dividend, included a sum of £8,000, which was derived from the sale of instruments by the Company, so that they had a considerable increase in their profits as compared with last year. There was one important feature to note, and that was that they had debited £6,645 as the cost of maintenance and renewals, but there was a very pleasureable fact in connection with that expenditure, and that was that the cost of maintenance proportionately to their income was slowly and surely reducing itself.

The motion was carried.

On the motion of the chairman, a dividend of 5 per cent., less income-tax, was declared payable forthwith.

The retiring directors, Messrs. F. W. Reynolds, G. H. Robertson, and Alderman Thompson, were reappointed. Mr. C. R. Trevor was re-elected auditor.

A vote of thanks to the chairman and directors terminated the proceedings.

COMPANIES' SHARE LIST.

TELEGRAPHS.

Companies.	Closing Prices Aug. 22.		Business Done Week Ending Aug. 22. Highest.	Lowest.
Anglo American	47½,	48½	48½	47¾
Do. Preferred	79½,	80	80	79½
Do. Deferred	17,	17½	17½	17¼
Brazil Submarine	11 11-16,	11 13-16	11 15-16	11¾
Cuba	11,	11½	11¼	11¾
Do. Preference	17½,	18½	—	—
Direct Spanish	5,	5½	—	—
Do. Preference	15¾,	16¼	—	—
Direct United States Cable	12¼,	12¾	12¾	12¼
Eastern Telegraph	10 11-16,	10 13-16	10¾	10¾
Do. 6 per Cent. Preference	12¼,	12¾	12⅝	—
Do. 5 per Cent. Debentures, 1899	103,	107	104¼	—
Eastern Extension	11 5-16,	11 7-16	11¼	11¾
German Union	9½,	10½	—	—
Globe Telegraph and Trust Company	7 5-16,	7 7-16	7 7-16	7 3-16
Do. Preference	12¾,	12⅞	12 15-16	12 11-16
Great Northern	12¾,	13	12 15-16	12¾
Indo-European	31½,	32½	—	—
Mediterranean Extension	1½,	2	1⅝	—
Do. Preference	2,	4	—	—
Reuter's	9,	9½	9½	9
Submarine	230,	240	230	—
West India and Panama	⅞,	1	15-16	⅞
Do. 1st Preference	6¼,	6⅝	—	—
Western Brazilian	5⅞,	6⅛	—	—
West. Union 7 per Cent. 1st Mortgage	122,	124	—	—
Do. 6 per Cent. Sterling Bonds	103,	108	—	—

TELEPHONES.

Companies.	Closing Prices Aug. 22.		Highest.	Lowest.
Consol. Telephone and Maintenance	5-16,	7-16	⅜	—
Oriental	5-16,	7-16	7-16	—
United Telephone	8⅛,	8⅜	8⅜	8⅛

ELECTRIC LIGHT.

Companies.	Closing Prices Aug. 22.		Highest.	Lowest.
Anglo-American Brush Lgt. (£7 paid).	3,	3¼	3 5-16	2 11-16
Do. (fully paid)	6,	6¼	6¼	6⅛
Hammond Light	1⅛,	1⅜	1 7-16	1 3-16
Eastern Electric (£4 paid)	½,	1	—	—
Swan	1¾,	2	2	1 13-16
Maxim-Weston	1-16	3-16	—	—

MISCELLANEOUS.

Companies.	Closing Prices Aug. 22.		Highest.	Lowest.
Telegraph Construction	33¼,	33¾	33⅝	33½
India Rubber, Gutta Percha, and Telegraph Works	28½,	29½	—	—

TRAFFIC RECEIPTS FOR JULY, 1883.

Companies.	July, 1883.	July, 1882.	Incrse.	Decrs.
Anglo-American Telegraph Company	—	—	—	—
Brazilian Submarine Company	—	—	—	—
Cuba Submarine Company	2,700	2,921	—	221
Direct Spanish Telegraph Company	—	—	—	—
Direct United States Cable Company	—	—	—	—
Eastern Telegraph Company	—	—	—	—
Eastern Extension Telegraph Company	36,177	30,070	6,107	—
Great Northern Telegraph Company	22,200	—	—	—
Submarine Telegraph Company	—	—	—	—
West Coast of America Telegraph Company	—	—	—	—
Western and Brazilian Telegraph Company	—	—	—	—

NUMBERS OF "THE ELECTRICIAN" OUT OF PRINT.—The following numbers of *The Electrician* are out of print, and cannot be supplied at the office, viz.:—Vol. 1, Nos. 3, 9, 19; Vol. 7, Nos. 8, 10, 12 to 18, 20, 21, 24 to 26; Vol. 8, 1, 3, 6 to 12, 15 to 26; Vol. 9, Nos. 2, 4, 24, 25; Vol. 10, No. 13.

THE LONDON PLATINO-BRAZILIAN TELEGRAPH COMPANY, Limited (River Plate and Brazil Telegraph Company).—NOTICE is hereby given that the half-yearly COUPONS which fall due on the 1st September, 1883, of £100,000 Seven per Centum Debentures of the River Plate and Brazil Telegraph Company will be PAID by Messrs. Glyn, Mills, Currie, and Co., 67, Lombard-street, in the City of London, bankers, on and after the 1st day of September, 1883, less income-tax. The Coupons must be left with Messrs. Glyn, Mills, Currie, and Co. for examination three clear days before the same can be paid.

By order,
WM. PAYTON, Secretary.

63, Old Broad-street, E.C., London,
23rd August, 1883.

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NOTES.

Cable Repaired.—The cable between Trinidad and Demerara is repaired.

Change of Address.—The St. George Telephone Company have removed to 20, Bucklersbury, E.C.

Direct Spanish Telegraph Company.—This company notify that their direct cable communication with Spain, *viâ* Bilbao, is now fully restored.

Electric Lighting in New York.—The Park Commissioners of New York have decided to light the Madison Avenue Bridge with electric lights.

The Duplex Company.—Mr. Justice Pearson has appointed Mr. William Waddell provisional official liquidator of the Duplex Electric Light, Power, and Storage Company.

American Telegraphs.—The New Hampshire Legislature has passed a resolution in favour of a government postal telegraph system, so says the Philadelphia correspondent of *The Times*.

Resignation.—Mr. L. A. Edwards, consulting engineer, of 57, Gracechurch-street, E.C., has resigned the post of mechanical engineer to the Metropolitan Brush Electric Light Company.

To be Wound-up.—The Electric Carbon Storage and Apparatus Manufacturing Company of Scotland, on the petition of Edward Mather, of the firm of A. Mather and Son, engineers, Edinburgh.

The Eastern Telegraph Company.—The Eastern Telegraph Company notifies that on and after 1st of September the rate to Buenos Ayres and other places in the Argentine Republic will be reduced to 10s. per word.

Incandescent Lighting. — The Brush-Swan Electric Light Company have introduced their storage battery into the Central National Bank in New York in connection with the Swan lamps.—*Sanitary Engineer*, New York.

Electric Lighting for Lighthouses.—An American paper says that a Government laboratory for tests connected with the introduction of the electric light into lighthouses is to be established at Tompkinsville, Staten Island.

A Patent Question.—The case of the Gramme Electrical Company of New York *v.* the Arnoux and Hochhausen Electric Company is being fought out in the United States Supreme Court, before Judge Blachford. The plaintiffs allege that the defendants have infringed the Gramme patent for dynamo machines.

Reductions in Tariff.—The West Coast of America Telegraph Company announce that the rate for messages *viâ* Galveston to Buenos Ayres and all stations in the Argentine Republic has been reduced to 10s. per word; and that the rate for messages to Valparaiso and all stations in Chili has been reduced to 10s. 8d. per word.

Insulating Wires.—Mr. E. T. Truman has recently patented a composition for insulating wires, which is made up as follows:—By mixing ozokerit with black lead, carefully dried, and gutta percha in the proportions of about ·3 of ozokerit to 10 parts black lead and 15 of gutta percha. The number of his patent is 5,757 for 1882.

Technical Schools at Nottingham.—The technical schools in connection with Nottingham University College will, it is expected, be ready for opening in October. In these schools the college authorities intend to give a complete course of instruction in mechanical and electrical engineering, and in the sciences most closely connected therewith. The workshops recently added to the college are to be supplied with steam power and lighted with the electric light.

New South Wales.—The report of the Postmaster-General of this colony for 1882 shows the revenue of the Postal Department to have been £229,910, that of the Telegraph Department £120,965. The expenditure, including interest on capital, for construction of telegraph lines was £528,736, and the lines erected during the year extended over 498 miles.

Telephonic Communication Between Rouen and Havre.—The French Ministry of Posts and Telegraphs has promised to erect a telephone line between Rouen and Havre, provided each place guarantees a return, in the shape of receipts, of the amount of 3,000f. per annum. Five hundred francs have already been promised by the Chambers of Commerce in both towns.

Adelaide Gallery.—This restaurant (Messrs. A. and S. Gatti) has been wired for about 320 Edison lamps and the electric machinery is about to be laid down. The plant will be in duplicate throughout. Two Field vertical multitubular boilers, two Armington and Sims' high speed engines, and four 150-light Edison dynamos will be placed in the basement adjoining the rooms to be lighted.

Books Received.—"Electricity and Its Uses," by J. Munro. Published by the Religious Tract Society, 56, Paternoster-row, E.C. We have also received a copy of a pamphlet, entitled "Electricity at the Board of Trade," by T. H. Blakesley, in which the author criticises the Board of Trade's method of carrying out the Electric Lighting Act; and "La Téléphonie en Suisse," par T. Rothen.

Microphonic Points.—Fused metallic sulphide of iron is said to make very good contact points for telephonic or microphonic purposes. Messrs. J. B. Spence and J. E. Chaster have recently taken out a patent for this. They take 32 parts by weight of sulphur to 56 of iron, and fuse the latter into the former, so as to render the result homogeneous. The number of their patent is 5,625 (1882).

The Late Mr. Spottiswoode.—The *Illustrated London News* states that the will of Mr. William Spottiswoode, President of the Royal Society, late of 41, Grosvenor-place, and of Combe Bank, Kent, who died on June 27 last, was proved on the 15th August by George Edward Eyre and George Andrew Spottiswoode, the brother, two of the executors, the value of the personal estate amounting to upwards of £187,000.

Electric Lighting in Printing Works.—We under, stand that Messrs. Fletcher and Son have decided to have their extensive printing establishment lighted by electricity on the Ferranti system. The work will be carried out by the Hammond Electric Light and Power Supply Company (Limited). We also understand that this company has obtained the order for the wiring of the Gilmour Institute, Alexandria, N.B.

Holborn Restaurant.—The Edison Company have for several months lighted a considerable portion of this restaurant with about 800 lamps, and arrangements are now in progress for laying down plant for upwards of 1,000 additional 16-candle lamps. The plant employed will be similar to that used at Messrs. Gatti's, but of proportionately larger capacity. When lighted throughout the Holborn Restaurant installation will be the largest of its kind hitherto made.

New Source of Caoutchouc.—The attention of the Indian Government has been drawn to a new plant, which is common in southern India, and yields abundant supplies of pure caoutchouc. It is an apocynaceous plant called

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Prameria glandulifera, the native habitat of which appears to be in the forests of Cochin China, where the liquid juice is often employed in medicine by the Annamites and Cambodians. When broken, the twigs are seen to contain an abundance of caoutchouc, which can be drawn out into threads, as in the East African Landolphias.

ELECTRIC LIGHTING AT BRADFORD.—An installation of incandescent lighting has just been completed at Blake's Restaurant under the Exchange. These are rooms greatly frequented by commercial gentlemen, who have already expressed their liking for electricity as opposed to gas. The installation consists of 100 Swan lamps of 20 candle-power. The supply of electricity is obtained from a 100-light Ferranti machine, which is excited by a D^s Siemens dynamo. The power is obtained from a 6 horse-power Crossley gas engine. Kingsland and Smith, of Leeds, are the engineers.

PARLIAMENT AND THE TELEGRAPH.—The work of the Telegraph Department in the House of Commons, says the *Daily News*, shows a considerable increase this year over any previous Session. The total number of private messages dealt with during the Session exceeded 35,000. This does not take into account press messages, which on one night of the Session amounted to over half-a-million words. The largest number of messages for foreign parts ever sent from the office were despatched on the Monday evening when Mr. Gladstone made his statement with respect to the Suez Canal.

THE MASON SCIENCE COLLEGE, BIRMINGHAM.—We have received a copy of the calendar of this college for 1883-84. The session opens on the 2nd October, when the prizes will be distributed, and Professor Poynting will deliver an address. The physics section is in the hands of Professor Poynting, with Mr. E. F. J. Love as demonstrator. The complete course extends over three years. A physical laboratory is provided in which students can repeat experiments performed in the class-room, and go through other practical work. Chemistry and metallurgy, theoretical and practical, are also taught; in fact, the college was originally founded for the study of practical science. In an appendix to the calendar are given the various papers set at the last examination in June. In the spring and summer terms some very useful work in electrical testing, and the management of dynamos and lamps is gone through.

A DESTRUCTIVE LIGHTNING FLASH.—The *Petersburger Zeitung* reports that a flash of lightning struck the stable attached to the cavalry officers' school at Krasnoje-Selo, and killed 16 horses on the spot. The flash on striking the corner of the building seems to have travelled along the iron with which the racks are covered and set all the hay on fire at once. The horses all fell to the ground. Most of them rose again quickly, but sixteen were found to be dead, and two were quite deaf. In all the horses that were killed the current seems to have entered at the head or neck, passing down through the fore feet. The horses killed were not all together or in adjoining stalls, but were scattered up and down the stable, justifying the presumption that their death was caused by their coming into contact with the metallic covering of the racks. The horses who survived were most probably not in contact with the metal at the moment when it was being traversed by the current.

GLASGOW COLLEGE OF SCIENCE AND ARTS.—In the recent technological examinations of the City and Guilds of London Institute, held at this college, Mr. J. M'Cowan, electrical engineering student, and Mr. W. H. Watkinson, electrical engineer, obtained first class honours in electric lighting. Mr. J. C. Binny, telegraphist (G.P.O.), was first (£3 and silver medal), and Mr. D. Mackie, telegraphist (G.P.O.), fourth (£1 and bronze medal), in the ordinary grade of telegraphy. In the science and art examinations, Mr. D. G. Fletcher (Messrs. Wallace, Tatlock, and Clark) got first class honours in chemistry (theoretical), Mr. Fletcher, and Mr. J. A. Anderson (Messrs. Wallace, Tatlock, and Clark), second class honours in practical chemistry, and Mr. Watkinson, second class honours in electricity and magnetism. A handsome gold medal has been offered for competition by John Pender, Esq,, M.P., to electrical engineering and telegraphy students completing their diploma next session, which commences October 1, 1883.

AN OXIDE OF COPPER BATTERY.—Messrs. de Lalande and Chaperon have designed a new single fluid battery, in which oxide of copper, caustic potash, and zinc are used. In the bottom of a glass jar is placed a cylindrical tray in which the oxide of copper is held. To this box a copper wire is fitted, which reaches to the top of the jar and forms one terminal. Where it passes the zinc it is insulated by being fitted with an india rubber tube. The zinc element takes the form of a spiral plate suspended from the cover and reaching half way down the jar. Where the zinc enters the liquid it is covered with india rubber to prevent its being eaten away at this point. The liquid contains from 30 to 40 per cent. of potash The E.M.F. of this class of battery is stated to be nearly 1 volt at first. Its resistance is small, and is estimated at $\frac{1}{3}$ or $\frac{1}{4}$ of an ohm for polar surfaces of 1 square decimeter, separated from one another by a distance of 5 centimeters. It is also stated that one of the small types of these batteries will give a current of nearly 2 amperes.

ELECTRICITY AND EARTHQUAKES.—Many people have put forward the hypothesis that earthquakes are used by the earth's electricity, and the recent seismic and volcanic disturbances which have occurred have once more brought this theory to the surface. Colonel Parnell has written a letter to the *Builder*, in which he quotes Humboldt, to the effect that Pliny believed earthquakes and thunderstorms to be due to the same cause. It appears that Dr. Stukeley, in 1750, was a strong advocate of this theory, as also was G. Beccaria, of Bologna, a contemporary of Dr. Stukeley's. We will quote the latter part of Colonel Parnell's letter for the benefit of our readers, though possibly they may not all agree with him. He says: "And if Beccaria's views should thus some 100 years after his death gain acceptance, nothing less than a complete revolution in our measures of defence against lightning strokes would have to be effected. 'Lighting conductors' would disappear; *electric taps* would supplant them; and measures of defence would be adopted against earthquakes."

NEW ELECTRO-DYNAMOMETER FOR ALTERNATING CURRENTS.—In *Wiedemann's Beiblätter*, M. Belatti describes a new and simple electro-dynamometer for very weak alternating currents. The needle of a galvanometer is replaced by a piece of soft iron wire, which tends to take up a position perpendicular to the plane of the magnetic meridian. If now the coils of the multiplier are set at an angle of 45deg. with the same plane, the iron wire will be temporarily magnetised by the circulating current, and will tend to take up a position at right angles to the plane of the winding in whichever direction the current flows. With an instrument in which the iron wire was replaced by a bundle of wires ·15mm. thick and 17mm. long, thoroughly annealed, and furnished with a mirror, with bifilar suspension 10cm. long, and hung in a coil 35mm. wide and 8mm. thick, of ·2mm. copper wire, good results were obtained. On generating a telephone current by means of a Siemens trumpet the deflection was too great

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to be measured, the index going beyond the scale. With ordinary intonation at 50cm from the telephone the deflection was apparent.

EARTHQUAKES.—A shock of earthquake of a rather severe nature, but of short duration, is reported to have been felt at Agram in Croatia at 3:40 p.m. on Tuesday last. It was accompanied by subterranean rumblings. From Batavia comes news that the Krakatoa volcano was in eruption on Sunday, the 26th August, and has since continued in that condition. A tidal wave is reported to have swept away the European quarter of Anjer and the Chinese camp at Merak. Telegraphic communication is now interrupted between Bantam and Batavia. Later news from Batavia, dated August 28th and 29th, says that all was then quiet, with a clear sky. Communication with Serang has been restored. The telegraph inspector reports that whilst trying to repair the line at Anjer early on the morning of the 27th, he saw a high column sea approaching with roaring noise, and fled inland. He knows nothing further of the fate of Anjer, but believes all lost. The lighthouses in Sunda Straits have disappeared, and where once Mound Kramatau stood the sea now plays. The Sunda Straits have been so altered in character, that navigation is reported to be dangerous.

NEW DYNAMO.—The *Scientific American* describes a new dynamo electric machine, the invention of Mr. A. Floyd Delafield, of Noroton, Connecticut, whose armature has neither wire nor bars, and in which no commutator is required, as the current flowing from the machine is all in one direction. The machine consists of a field magnet having hollow cylindrical polar extremities, in each of which a tubular armature revolves, the bearing of the armature being at the ends of the cylindrical poles of the field magnet. An auxiliary field magnet composed of the side bars and cylindrical pole extensions extending through the armature axially completes the arrangement, and acting together with the outer magnet produces a strong magnetic field surrounding the armature on all sides. The current is conducted away from the ends of the armature by wires connecting with the armature journals, and with springs bearing on the ends of the armature. The springs are applied to insure a constant connection. In operating the machine the current from one armature may be used to excite the field magnets, or the current from both armatures may be taken through the wire of the field magnets, or if used for lighting purposes, the field magnets may be excited by a small high tension dynamo, and the entire current of the armatures may be applied to outside work. Our contemporary adds that the current from this machine is uniform and continuous, and always in the same direction, so that there are no reversals or interruptions and consequently no sparks.

THE KINEMATICS OF DYNAMO MACHINES.—In No. 11, Vol. V. of the *Centralblatt* for 1883, Professor Rittershaus compares dynamo machines with steam-engines, the commutator corresponding to the slide valve, or four-way cock, or other arrangement for regulating the steam supply. The currents induced in the separate coils of the machine are always alternating in direction, this being reversed at the moment of the passage of the particular coil through the neutral part of the field; these alternating currents are then collected by the commutator. The commutator in its simplest form—for one coil and two fields—is exactly the equivalent of the four-way cock; two conducting pieces on opposite sides correspond to the steam passages. If the machine has two coils with two fields, and if these are opposite to each other, so that they pass the neutral diameter simultaneously, the commutator may serve for both. The coils will then be joined up parallel, and the brushes form the connection with the outer circuit. This corresponds to a two-cylinder engine, the pistons of which are united by a cross head, and are regulated by a single four-way cock. In compound steam-engines there must be one six-way cock or two four-way cocks, and these engines may be looked upon as connected in series, the steam passing from the high-pressure cylinder to the low-pressure cylinder. In the same way the coils of a dynamo machine may be coupled in series by means of two commutators. If there are more than two coils, a separate commutator may be provided for each coil or for each pair of coils, as has been done by Brush; or the several currents may all be united in one common distributing apparatus, as has been done for steam in Brotherhood's three cylinder engines. The author traces similar analogies in other machines.—*Journal of the Society of Telegraph Engineers.*

STEAMSHIP LIGHTING.—The Edison Company have contracted for the lighting of the steamship "Valetta," now being built by Messrs. Caird and Co., of Greenock, for the Peninsular and Oriental Company. Two hundred and fifty 16-candle lamps will be used, and the generating plant will consist of two high speed engines, driving two Edison 150-light dynamos. The company have also closed contracts for the lighting of H.M. troopships, "Serapis" and "Crocodile." Two sets of high speed engines and two Edison 250-light dynamos will be employed on each vessel. The total number of lamps in each case will be about 400, partly of 16 and partly of 8 candles. This contract is the immediate result of the satisfaction given by the company in their installation on board H.M.S. "Malabar," recently fitted throughout with the Edison system. The largest contract for electrical plant on board ship yet given out has recently been secured by the Glasgow agency of the Edison Company. This is for the lighting of three large steamers building by Messrs. Elder and Co. for the New Zealand Shipping Company (Limited). Each steamer will be fitted with 200 to 250 lamps, and the engines and dynamos will be duplicated in each case. In all the foregoing installations the dynamos employed will be of the special slow speed type for marine use, giving an electromotive force of 110 volts at 500 to 600 revolutions per minute. The steamship "Apollo" and "Minerva," for the Compagnie La Platense; the steamship "Takapuna," for the Union Steamship Company of New Zealand; and the steamship "Clan M'Intosh," for the Clan Line, have all recently been fitted throughout with the the Edison Light, and in each case the greatest satisfaction has been expressed by the owners in regard to the working of the system. The "Clan M'Intosh" is the second, and the "Takapuna" the third of their respective lines lighted by the Edison Company.

TELEGRAPHIC INSTRUMENTS IN PUBLIC HOUSES.—In the House of Commons on Thursday, August 23, Mr. Hopwood asked the Secretary of State for the Home Department whether his attention had been drawn to the fact that the police in the metropolis had been threatening licensed victuallers with opposition to their licenses at the annual meeting, unless they at once gave up the receipt of general, sporting, parliamentary, and Stock Exchange news by the automatic news-transmitting instrument (such as is in use in clubs), and for which a considerable annual payment is made; whether, in one of the instances referred to, the police went through the premises, taking down the names and addresses of persons found there; whether he would state by whose authority those proceedings took place; and

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whether he would sanction their continuance?—Sir W. Harcourt: Yes, sir, I have a report from the police on this subject. It is the duty of the police to put down betting houses; and they report to me that, in consequence of various complaints from the inhabitants of the number of licensed houses used for the purposes of betting, the holders of licenses had been cautioned that if facilities were given by means of telegraphic instruments for betting, summary proceedings would be taken against them before a magistrate, or by opposing the renewal of the license, as the facts may warrant. —Mr. Cowen said he understood that public houses were not to be forbidden the use of telegraphic communication.—Sir W. Harcourt: They will not be forbidden if the instruments are not used for betting purposes. They may have telegraphic communication for reporting the proceedings of this House, for example.—Mr. Hopwood: The threat is that if they do not give up these instruments their licenses will be opposed.—Sir W. Harcourt: Only if their instruments are made the means of betting, and are used for that purpose.—Colonel Carington gave notice that he would ask the Home Secretary whether licensed victuallers were to be prevented, by menaces on the part of the police, from using telegraphic machines which were in use in all clubs, and in many private houses?

Sleeping with the Head Northwards.—*Les Mondes*, in quoting our note concerning the beneficial effect of sleeping with the head to the north and feet south, reminds us that the idea is no new one. Our contemporary says that Dr. Maire, of Havre, wrote in a footnote to a work published in 1866 the following:—"An old doctor who has just died at the age of 107 years, and who had promised to make known before his death the secret of his longevity, pointed out that the great way to attain this result was to place the bed north and south, in the direction of the great magnetic currents of the globe, and to let it remain there for a long time. Perhaps we ought not to laugh too much at this precaution, and to believe it of no consequence. If I had the time I would tell you of an experiment in mineral magnetism, which was very successful in alleviating severe neuralgic pains, when the magnet was applied in the direction indicated, and which led to no result if the patient faced the east or west." Our contemporary adds that as to this latter experiment, even if we doubt its efficacy, we cannot regard it as a novelty, for in 1783 Sigaud de la Fond wrote as follows:—"Towards the end of 1765 it was discovered that magnetic virtue had the property of curing toothache. Many gave evidence in favour of this new practice, but it was not confirmed in France till after the cures effected by M. Klarik at Gottingen, because we are told at the same time that there was a particular method of administering the remedy, and one essential to its effect. It consisted in directing towards the north the face of the person operated on, and touching the tooth affected with the south pole of a magnet or a magnetic bar. Since this time, cures, which previously were only effected by chance, have been multiplied, and numbers of persons, worthy of belief, testified to and confirmed the efficacy of the remedy." Our contemporary concludes:—"As will be seen it is possible that the recent experiments (mentioned by us) may be a little ancient. Meanwhile, not having repeated any of them, we, of course, do not guarantee one or the other; on the other hand, we should not care to say that in all this there may not be some good."

Underground Wires in Philadelphia.—A trial of the Brooks system of laying underground wires was made at Philadelphia a few days ago. As we have previously explained to our readers, the Brooks system consists in laying a number of wires previously insulated with shellac and cotton wrappings, in a conduit, into which oil is forced and afterwards maintained by gravity, a reservoir of this liquid being connected with the conduit. In Philadelphia one of these conduits has been laid from Third and Chestnut-streets to the Kensington Railroad depot, at Front and Norris-streets, a distance of more than two miles. The *Philadelphia Ledger* gives the following account of the recent trial:—"There are thirty-three telegraph and telephone wires in the conduit that has just been laid. These terminate at Front and Norris-streets and in the basement at the north-east corner of Third and Chestnut-streets. In the latter place ten of the wires are connected with telegraph instruments simply to show their workings. Others are connected with telephones, and through these conversation was carried on with people at the Kensington depot. Over the metallic circuits there was no trace of induction from the telegraph instruments, and on a single wire, or grounded circuit, the induction, though appreciable, did not interfere with the use of the telephone. It is stated that ten of the wires are now in practical use by the Western Union Telegraph Company on through business. The lines pass overhead from Tenth and Chestnut to Third, thence through the Brooks conduit to Front and Norris streets, and thence to New York by the ordinary overhead route. These lines were in use yesterday at the time of the experiments with the telephones, and it is stated by Mr. Brooks that the Western Union Company intends to make an 'effectual trial use' of the system. It is also stated that the system is to be extended to other streets, and that conduits carrying from 100 to 150 wires will be laid. This will largely reduce the cost per mile of wire." The Brooks system is now in the hands of the Brooks Underground Conduit Company, by whom the above work was carried out. We notice that our friend Mr. David Brooks is the president of the company, and are glad to be able to record his success. In America overhead wires are far more numerous than they are in England, and any successful and economical system for placing them underground, without interfering with their efficiency of working, will be hailed with pleasure.

Irish Telegraph Clerks.—In the House of Commons on Thursday (Aug. 23), Mr. A. O'Connor asked the Postmaster-General what was the number of clerks in the Telegraph Department of the Belfast post-office with less than nine years' service, who were allowed three weeks' annual leave, and the number with over nine, and not exceeding thirteen years' service, who, though performing the same duties, were only granted a fortnight's annual holiday; also the number of clerks in the postal department of the same office with service not exceeding thirteen years who were granted one month's annual leave; and whether there was a single instance of a clerk with long service and good conduct having been transferred from any provincial office to the telegraph department of the Liverpool, Manchester, or Glasgow post-offices, being called upon to perform night duty, and only allowed a fortnight's annual holiday; and whether in Irish offices, such as Dublin and Belfast, where the duties were precisely the same as in the offices referred to, officials were treated differently in this respect?—Mr. Fawcett: The first of the two questions put by the hon. member is similar to one that was addressed to me at the beginning of last month. I then explained that the reason for some of the telegraphists in the Belfast post-office having three weeks' leave, while the rest have a fortnight, was that at Belfast some officers had received

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through an error longer leave than was given at other post-offices. As soon as the mistake was discovered new intrants into the Belfast post-office were put into the same position with regard to leave as those employed elsewhere. It was not, however, thought expedient to withdraw the longer leave from those who had previously enjoyed it. I also stated that in consequence of the postal duties being much more harassing than those of the telegraphists, some of those employed on the postal side have more than a fortnight's leave. With regard to the hon. member's second question, I have not been able during the short interval which has elapsed since notice of it was given to collect the required information from the post-offices of Liverpool, Manchester, and Glasgow; but I may say generally that the post-office servants in those cities are not treated exceptionally in the matter of leave, and that throughout the United Kingdom, wherever the circumstances are similar, similar treatment is extended to all.—Mr. A. O'Connor asked whether the right hon. gentleman would take notice of a case of distinct unfairness if it were brought before him?—Mr. Fawcett said if the hon. gentleman would direct his attention to a particular case, he would most gladly have it investigated.

Launch of a Government Cable Steamer.—Messrs. D. J. Dunlop and Co., Port Glasgow, launched, on Tuesday week, a fine screw steamer to the order of Her Majesty's Postmaster-General, to be employed in laying telegraph cables. The dimensions are:—Length between perpendiculars, 240ft.; breadth (moulded), 33ft.; depth from keel to underside of deck amidships, 20ft.; tonnage, B.M., 1,348 45·94. The new steamer has a raised quarter-deck of the height of the main rail, about 66ft. long; a monkey forecastle about 19ft., and hurricane deck 100ft. long, with deck-houses below. She is to be rigged as a two-masted schooner, with pole masts, is fitted with three circular cable tanks, has a partial double bottom built on the cellular principle, and is divided into six water-tight compartments. The steamer will be fitted by the builders with a pair of compound inverted cylinder engines of the collective indicated power of 1,000 horses. She will also be fitted with Messrs. Napier's patent screw steering apparatus, made to disengage in the most approved manner when the steam gear is connected. The steam steering gear on the hurricane deck is of Messrs. Amos and Smith's manufacture, and she is fitted with a Napier's patent steam capstan windlass. Special attention has been given to the manufacture of anchors and cables, the anchors being Inglefield's patent stockless, and the cables Messrs. Ingley's special best quality. The vessel has eight boats, including a steam launch; and to facilitate the working and lowering, Barry's patent davits have been provided for each, manufactured by the builders. The accommodation for officers and crew is—Under the quarterdeck aft, four spacious state rooms, handsomely furnished and well ventilated by square ports, are provided for the cable officers, together with a handsomely-fitted airy saloon and various offices for carrying on her special services. The accommodation for officers and engineers is provided in a large teak deckhouse amidships, and is suitably fitted up in such a style as to ensure the utmost comfort. In the 'tween decks forward there is accommodation for the petty cable officers, firemen, and crew, all of these places being well and comfortably arranged. The ceremony of naming the vessel the "Monarch" was performed by Mrs. Cunynghame, wife of Mr. A. Cunynghame, Surveyor-General for Scotland. Amongst the distinguished party who witnessed the launch were the Earl of Shaftesbury, Lady Edith Ashley, the Hon. Lionel Ashley, Mr. John Burns, Castle Wemyss; Mr. and Mrs. Dunlop, Mr. C. H. Patey, secretary of the Telegraph Department; Mr. E. Graves, engineer-in-chief to the Post Office; Mr. A. Cunynghame, Surveyor-General for Scotland; Mr. Hobson, postmaster, Glasgow; Mr. J. H. Ritchie, architect to the vessel; Mr. David Lumsden, submarine superintendent, General Post Office; Mr. W. R. Culley, assistant submarine superintendent, and others. The cable machinery with which this vessel will be fitted has been designed and is being made by Messrs. Johnson and Phillips, of Charlton.

A Private Telephone Line.—Passengers from Glasgow to Wemyss Bay having good eyesight and fair perceptions may make themselves acquainted with the newest feature of telephonic science. Mr. John Burns, of Castle-Wemyss, has recently had provided for him by the Post Office telephonic communication between his office in Jamaica-street, Glasgow, and his house at Wemyss Bay, on the most approved principles. A distance of 32 miles, it is the longest private wire in the world, but the perfection of the work also makes it the most perfect. It is no exaggeration to say that, no matter how many trains may be passing along the railway, and however many telegraphic messages may be careering along the wires on the poles, the Castle-Wemyss private wire keeps itself absolutely free of all of them, and attends to its own business. The arrangements producing this most desirable result may be seen from the windows of the moving train. The Castle-Wemyss private wire is what is known as a metallic circuit—that is to say, it consists of two wires, through which the current of electricity passes round and round, up one wire and down the other, and always in the same direction. The two wires are "twisted," as it is called. They are not allowed to touch each other, of course, but they revolve round each other as they are carried from post to post. To understand the process it is necessary to imagine four positions on one of the arms of each of the telegraphic posts, and these may be indicated by A, B, C, D. The up wire, we may suppose, is suspended on insulator A, and the down wire on insulator D on the first post. On the second post the up wire is fixed to insulator B, and the down wire on C. At the third post the wires are fixed, the up on D and the down on A. At the fourth post the wires are fixed on B and C, and at the fifth post they assume their original relative position, having made a complete circuit of each other in precisely the same way as two strands of a rope encircle each other, but by the tension with which they are suspended they of course do not touch each other. Having strung the wires in this manner, it will be observed that no other wire on the poles can come near to the up wire without within four-poles distance coming within precisely the same relation to the down wire. The result of this arrangement is that induction is prevented, or rather neutralised. The telephone used at either end—in Jamaica-street, Glasgow, and at Castle-Wemyss—is an ordinary Gower-Bell telephone, supplied by the Post Office. The transmission of sound is perfect, and there is, indeed, less difficulty about hearing through this long distance of thirty-two miles than there is in many of the short circuits. One curious fact in connection with the use of this telephone illustrates in a remarkable manner its perfection. Although many trains may be passing up and down the line when the telephone is in use, the noise made by them has no effect upon the delicate vibrations passing from voice to ear. On the other hand, a train passing the window of the telephone-room in the Cunard office, which is in close proximity to the central station in Glasgow, is heard distinctly at Wemyss Bay, and puts a stop to conversation for the moment until it has passed, unless the sound caused by the passing train can be shut out from the room where the telephone is placed.—*Glasgow News.*

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THEORY OF MAGNETO AND DYNAMO MACHINES.

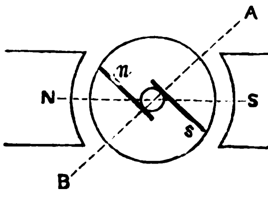
XXIII.

When discussing the motion of a conductor caused by a current or the E.M.F. generated by the motion of a conductor across lines of force—for instance, the revolution of a coil or of an armature in a magnetic field—we took the field as given without discussing how it was produced; in other words, we considered it as an independent field either of the earth or of a magnet, which preserved its strength and direction undisturbed by any effect of the current in the moving conductor itself (see Arts. IV., V., VIII., XIII., XIV., XIX., XX.).

Now, it is plain that currents flowing round a ring or an armature have some magnetic effect, and they consequently affect the field in which they are generated. Hence the intensity of field F or I in all the foregoing expressions is not simply the impressed or applied magnetic field, but is the *resultant* intensity, compounded of this and of that due to the current which is either producing the motion or is being excited by the motion. If the current is weak, as when the circuit is unclosed, or when it is only closed through high resistance, the disturbance of the magnetic field is zero or negligible; but in the case of an armature carrying a strong current, the magnetic effect of the armature is by no means negligible, and the resultant magnetic field in which it rotates is by no means that due to the field-magnet alone.

We have not yet had occasion to inquire particularly how the magnetic field F arose, but as soon as we do we must remember that, in the formulæ of Art. XX. for instance, F stands for the resultant magnetic field produced by armature and field magnet together, and that it is only simply that due to the magnet for the case when the circuit is open and no current allowed to be generated.

Refer to the diagrams in Art. XIX.,* especially Figs. 1 and 2 say, the lines of force of the undisturbed field will run from N on one of the field magnet poles to S on the other. Remove the field magnet and send a current round the armature as indicated by the arrows, it is magnetised in the direction of the letters S N drawn on the armature. Now replace the field magnet, holding the armature still, and draw the resultant lines of force through the armature; they will be nearly vertical, and will run from bottom to top. But the brushes (slightly indicated in Fig. 1) will no longer be in the neutral position, as they ought to be, and there will be waste of power and sparking. To make things right, and restore the lines of force to their proper position along the line of brushes, the simplest plan will be to suppose the field-magnet poles shifted round a little in the clockwise direction until the line joining the poles is about horizontal.



The amount of shift needed will, of course, depend on the relative magnetic strengths of the field magnet and armature, but the direction of the shift is the main thing now to notice, and it is the same for all the diagrams in Art. XIX.

A B is, in each figure, the line of brushes or the neutral line,† *N S* in the skeleton diagrams is the line of magnetisation of the armature, and the field magnet poles may be considered as horizontal, instead of along the neutral line as shown in Figs. 1 and 3. By studying the arrows it will be perceived that the current in a coil is reversed when its plane is perpendicular to the lines of force, *i.e.*, when a maximum number of lines pass through it, or when a small motion makes it cut none.

The angle between the line of poles and the neutral line is technically known as the "lead." If the field magnets are very much stronger magnetically than the armature the lead is small. In series machines the total current flows round both armature and field magnets, and consequently their strengths change together as the external resistance is varied, and the lead is fairly constant. In shunt machines, on the other hand, the current round the field magnet is quite different to that round the armature, and accordingly the lead is apt to vary for different strengths of current in the external circuit, being least for high external resistance or open circuit.

The account of the lead is not yet complete, however; there is a certain lagging in the induced magnetism and currents of the armature behind the forces exciting them, an effect analogous to inertia, which requires the brushes to be shifted round in the direction of rotation; and this effect may either increase or decrease the lead already mentioned according to the direction of rotation. This part of the lead, therefore, depends on the speed, being nothing when the armature is held still.

The first part of the lead (which is ordinarily the greatest) is not much affected by holding the armature of a motor still, and it disappears only when no current is flowing in the armature. The second part of the lead is greatest when the armature contains much iron, especially if it is not thoroughly soft; but it is not zero even when there is no iron core, for there is still a lagging of the current behind the E.M.F., due to self-induction.

The first part of the lead, viz., that due to the proper magnetisation of the armature by its own current, I shall call the static lead; this is independent of the direction of rotation. The second part, due to lagging magnetism, or "self-induction," or inertia, I shall call the "lag;" this is always in the direction of rotation.

The direction of rotation we have so far regarded as undecided. I have supposed the current direction fixed, and, therefore, the static lead as fixed. But if the machine is supplied with currents, and magnetised as shown in the figures, it is perfectly easy to see which way it *wants* to turn —viz., clockwise. Considered as motors, therefore, the rotation of the armatures in the diagrams is clockwise; but, considered as dynamos, the armature must be driven the other way, in the direction that the currents magnetically oppose.

In practice the brushes are shifted instead of the magnet poles, and accordingly it is easy to see that the static lead requires them to be shifted *with* the rotation in a dynamo, against the rotation in a motor. The first is called a positive lead, the second a negative lead. The lag part of the lead is always positive, and has to be added to the other part in a dynamo, subtracted in a motor.

Now, there is this rather important thing to notice with respect to the lead, viz., that the magnetic axis of the armature and the magnetic axis of the magnet are turned by it so as partly to oppose one another; their similar poles being nearer together than if there was no lead. Hence the field magnets are rather weakened than strengthened by the magnetism of the armature. A large amount of lead is thus a disadvantage, and it is sometimes possible to get a higher E.M.F. by setting the brushes with too little lead, notwithstanding that there is then a good deal of flashing. The flashing not only means waste of power but it means burning away of working parts, hence it can hardly be recommended as economical to increase the effect by diminishing the lead. The effect of "lag" in a dynamo is still further to increase the lead, but in a motor it diminishes it. A motor has this advantage therefore over a dynamo, and at very high speeds it is even possible that its proper resultant lead may be zero or even positive, in which case the magnetisation of the armature will help the field magnets instead of weakening them.*

The rule for direction of rotation is most easily stated thus:— If a battery current be sent round an armature in the same

* Nov. 18, 1882.

† We here assume that the neutral lines of armature and of commutator are perpendicular: whether this is so or not in practice is a detail of construction, for obviously the commutator may be set on at random with reference to the armature. The neutral line in the armature is the direction in which the coils do not cut lines of force, and it is simplest to suppose the commutator set on so that the line of brushes shall correspond with this direction in the Gramme, and be perpendicular to it in the Siemens.

* This fact was pointed out by Profs. Ayrton and Perry, who have utilised it to the utmost in their motor.

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direction as that generated by a specified rotation it will begin to rotate the other way, unless the field magnets are simultaneously reversed.

Now, in a permanent or separately excited dynamo they are, of course, not reversed; neither are they in an unmodified series dynamo by a current in the same direction as itself produced. Consequently in all these cases the direction of rotation is just the opposite when used as a motor to what it is when used as a dynamo.

In a shunt dynamo, on the other hand, a current sent the same way through the armature will flow the other way round the field magnets, and therefore in a shunt motor the armature revolves as it did when a dynamo.

In a permanent or separately excited machine used as a motor a reversal of the current reverses the direction of rotation, but not so in a self excited machine whether shunt or series. Accordingly, however, a battery current be sent through a self-exciting dynamo, it will begin to run *against* the brushes if a series, *with* the brushes if a shunt machine, always provided the connections between armature and magnets remain unaltered.

To reverse the motion it is useless simply to reverse the whole current; the only plan is to reverse the connections either of the field magnet or of the armature alone.

Now, as there is an obvious practical objection to running the armature against the brushes, the best way when using a series machine as a motor is first to reverse its field magnet wires. With a shunt machine no change whatever is necessary, and it cannot help running right.

Similarly, when charging a secondary battery with a shunt machine, it matters not which way you connect the battery to it; the cells will always get charged if the machine is driven fast enough, and they will always help the engine to drive it, whether it be going fast or slow.

THE NEW PATENT LAW.

Mr. J. Henry Johnson, patent agent, of 47, Lincoln's Inn-fields, W.C., has favoured us with the following *résumé* of the recently-passed Patent Bill:—

The Act to amend and consolidate the law relating to Patents for Inventions, Registration of Designs and Trade Marks, will come into operation 1st January, 1884. It repeals wholly or in part no less than 23 statutes, and by simplification of procedure and reduction of fees effects great changes. Although the Act provides for certain alterations in the existing laws of trade marks and designs, the following remarks are confined to the one subject of patents for inventions. There has been no substantial alteration in the Patent Laws since the Act of 1852, although numerous Bills have been introduced into Parliament by the various Governments and private members. The amendments now effected are to a very considerable extent those recommended by the Committee of the House of Commons in 1871.

The main alterations effected as regards the law of patents are as follow: The Government fees on application for provisional protection are reduced from £5 to £1, and the Government fees for completing the patent for the first term (four years in place of three as at present) are reduced from £20 to £3, so that the patent will be granted for a term of four years for a sum of £4. There is no alteration in the amount of the subsequent payments for the extension of patents from four to fourteen years, but in place of paying the £50 and £100 duties in lump sums at the end of the third and the seventh year, these sums are now payable at the option of the patentee either in one sum of £50 at the end of the fourth year, and one sum of £100 at the end of the eighth year, or by annual payments of £10 before the end of the fourth, fifth, sixth, and seventh years; £15 before the end of the eighth and ninth years; and £20 before the end of the tenth, eleventh, twelfth and thirteenth years. Patents will be granted to the inventor jointly with others, but the inventor must in every case make a declaration that he is the true and first inventor. Applicants for patents may, if they so think fit, transact all their business with the Patent Office by post, and the various post-offices throughout the country are to keep on sale the stamped papers required in applications for patents. Each application for a patent is to be confined to one invention only.

The procedure on application is as follows:—The inventor must lodge at the Patent Office a declaration and provisional specification. These documents, in place of being referred to the law officers for examination, are to be referred to an examiner. This examiner's duties are to see that the provisional specification fairly describes the invention, and to see that the title of the invention sufficiently indicates the object of the invention. The examiner has also to report to the comptroller (the officer at the head of the Patent Office) whether the application conflicts with any other unsealed application in the office.

The provisional specification having been approved, the applicant must then prepare his final specification, and lodge it at the Patent Office within nine months from the date of application. This specification is again referred to an examiner, who has to ascertain that the specification is properly prepared, and is consistent with the provisional specification. The examiner, in the cases of both provisional and complete specifications, is to report to the comptroller. If the applicant is dissatisfied with the decision in either case he can appeal to the law officers. If the complete specification be not accepted within 12 months from the date of application the application is to become void.

The patent is sealed after the final specification has been passed by the comptroller.

The provisional specification remains secret until the complete specification is filed, but after that both provisional and complete specifications are to be open to public inspection.

Specifications may be amended by way of disclaimer, correction, or explanation. The comptroller is to decide upon all applications of this nature, there being an appeal from his decision to the law officers. A very important provision is also introduced for the purpose of enabling the patentee to disclaim, by leave of the judge, during the progress of an action, and without stay of proceedings.

The Board of Trade has power to grant compulsory licenses in default of the patentee granting licenses on reasonable terms, and on proof that (*a*) the patent is not being worked in the United Kingdom; (*b*) the reasonable requirements of the public are not supplied; (*c*) any person is prevented from working or using to the best advantage an invention of which he is possessed.

The jurisdiction of the Privy Council in cases of prolongations of patents is retained, but the almost obsolete power given to the Privy Council to confirm patents is not re-enacted.

The action of *scire facias* is abolished, but revocations of patents may be obtained on application to the Court.

The right of the Crown to the free use of patented inventions is abolished, but the Crown is to be at liberty to use patented inventions on terms to be settled by the Treasury.

In all legal proceedings with respect to patents the Court may, and at the request of either party shall, call in the aid of an assessor.

Letters Patent may be granted to the personal representatives of deceased inventors.

The clause of the Patent Law Amendment Act, 1852, by which the British patent lapsed with the expiry of any foreign patent of anterior date is not re-enacted.

The provisions as to the registration of documents at the Patent Office, the printing and publication of specifications, and the preparation of indexes and abridgments are not substantially altered.

The comptroller is to issue an illustrated journal of patent inventions, as well as reports of patent cases, and is to keep this journal and complete specifications of all patents in force, on sale.

Power is taken to join the International Union for the reciprocal protection of patents, and when this is done the anterior publication of a foreign specification will not (for a limited time) affect the British application.

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A NEW MAGNETO CALL-BELL.

M. Abdank-Abakanowicz, whose name is not unknown to the readers of our paper, has recently designed a new magneto call-bell, the action of which will be readily understood from the following description and illustrations :—

The transmitter (Fig. 1) is composed of a U-shaped electro-

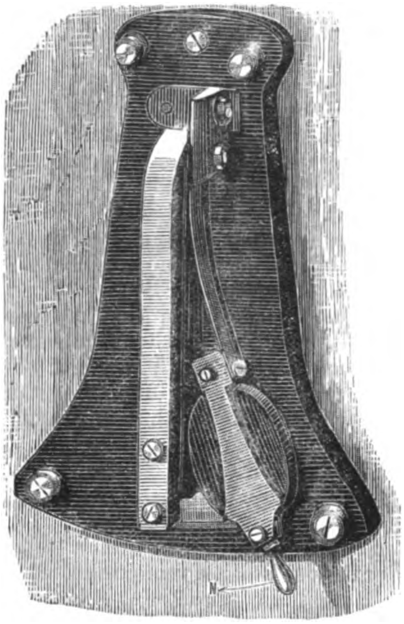

FIG. 1.—The Transmitter.

magnet, between the arms of which a bobbin furnished with an iron core and fixed to the end of a spring whose other extremity is securely fastened to the support of the apparatus is free to move. The bobbin is displaced from its position of equilibrium between the arms of the magnet by pressing the button shown at the lower part of the bobbin, and is then left to itself. Under the action of the spring the

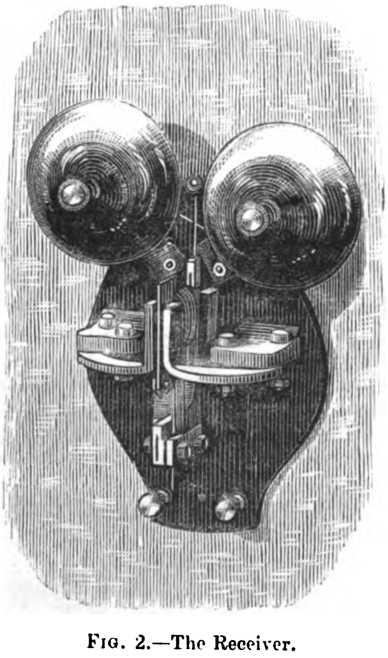

FIG. 2.—The Receiver.

bobbin oscillates rapidly like a pendulum between the arms of the magnet, and the wire on it is traversed by a series of alternate and undulatory currents, which last for some seconds until the bobbin returns to its position of repose.

The undulatory currents thus developed enter the receiver (Fig. 2), which is formed of a second bobbin wound on a sheet of iron cut into the form of a double T, and moves in a magnetic field formed by two permanent magnets. This double T piece carrying the bobbin is fixed on a spring, which serves to regulate its vibrations, and renders them more or less synchronous with those of the transmitter, thus increasing the sensitiveness of the apparatus. The other extremity is furnished with a small brass ball, which strikes the two bells alternately when the bobbin is traversed by the undulatory currents supplied by the transmitter.

As will be seen, the apparatus is extremely simple, and it is claimed for it that it will work well in any position and without much looking after.

THE ELECTRIC RAILWAY AT BRIGHTON.

We mentioned the fact that an electric railway had been constructed at Brighton by Mr. Magnus Volk, electrical engineer to the corporation of that town, in a recent note. The following additional particulars will no doubt prove interesting to our readers.

The line was constructed very hurriedly; how hurriedly may be judged from the fact that the line was laid, the car, dynamo, and motor built, and the engine and dynamo fixed in their places in about 18 days. The generator is a Siemens D^5 machine, having an E.M.F. of 55 volts, and giving a current of 18 amperes at 1,700 revolutions per minute. One of Crossley's gas engines of 2 horse-power is used to drive the dynamo. It has two fly-wheels, and runs at 160 revolutions per minute. The dynamo, which is used on the car as a motor, was constructed by Mr. Volk; it weighs about 2¾ cwt., and runs at 700 revolutions per minute. The pulley is connected by means of a belt to a countershaft, from which another belt runs to another pulley fixed on one of the axles. The pulley of the motor is 5in. in diameter, that on the countershaft 10in., and that on the axle 12in. The speed of the car up an incline of 1 in 100 is about five miles an hour, the return journey down the incline being made at the rate of ten miles an hour. The car carries twelve passengers, exclusive of the driver; it has carried as many as sixteen persons, however. It is lighted at night by a 20 candle-power Swan lamp.

Reversal is effected by means of a commutator switch, which introduces a number of resistances into the circuit before breaking it, thus greatly diminishing the sparking. The same lever which actuates this switch also alters the lead of the brushes, of which but one pair is used. The wear of these brushes has been so slight that they only required to be removed after three weeks nearly continuous running.

The track is about a quarter of a mile long, and rests on the shingle; ordinary flange rails and longitudinal sleepers are used. The rails are connected by No. 8 copper wire loops bolted on with ⅜in. bolts.

On the last Bank Holiday, 6th August, the car ran for eleven hours without a break. During this time it conveyed 1,200 passengers and covered fifty miles. Since that date it has continued running every day without interruption up to the present time. The loss of current even during a wet day does not, we are told, exceed 10 per cent., and in dry weather is less than 5 per cent. The rails alone are used as conductors, and the wet weather has not interfered with the working in the least.

The following table gives some details concerning the current, weight of car, &c., which are interesting :—

Engine, 2 horse-power nominal, about	3½ indicated.
Current	18 amperes.
E.M.F.	55 volts.
Weight motor	2¾ cwt.
„ car	7 „
Load 12 persons	1 ton.
Gradient	1 in 100.
Speed mean	7 miles per hour.
Daily journey	25 to 30 miles.
Daily average number of passengers	350.

Application is now being made to extend the system the whole front of Brighton under the Esplanade wall—a distance of two miles, and to run cars in both directions

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every 10 minutes; and also to have an electric hoist to convey passengers up the face of the eastern wall, a height of 62 feet.

The cost of carrying 12 passengers 60 journeys of half mile each, *i.e.*, 12 passengers 30 miles, or one passenger 360 miles, is stated to be as follows:—

Gas, 10 hours at 3d.	2s. 6d.
Oil and waste, total	0s. 8d.
Conductor	3s. 4d.
Labourer to clean and attend to engine, repair shingle track, &c.	4s. 2d.
Depreciation, 15 per cent. on £500, say	5s. 0d.
	15s. 8d.

or a trifle over ½d. per mile. As the car at present runs for five minutes only and then stands five minutes, its carrying capacity can be multiplied by two, in which case the only increased expense would be the cost of 50 per cent more gas, the cost in wages remaining the same, so that the cost is only a trifle over ¼d. per mile per passenger, supposing it runs full every journey.

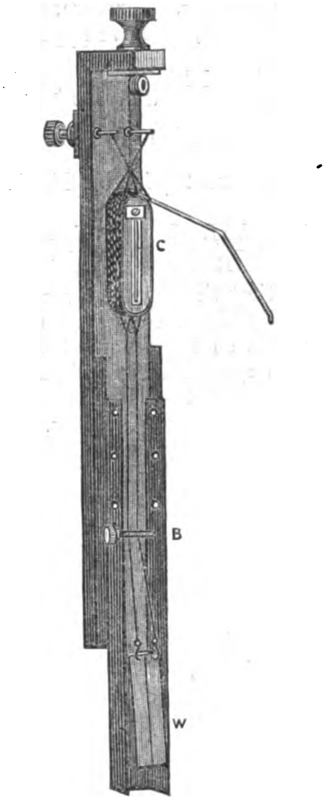
For the particulars given above we are indebted to the kindness of Mr. Volk, who, we think, is to be congratulated upon the success that has attended the first electric railway at Brighton. We hope that its proposed extension will be carried out at no distant date, and that its working will continue to be successful.

ON THE DETERMINATION IN ABSOLUTE UNITS OF THE INTENSITIES OF POWERFUL MAGNETIC FIELDS.*

By A. Gray, M.A., F.R.S.E., Chief Assistant to the Professor of Natural Philosophy in the University of Glasgow.

So far as I know, no method has yet been published by which the intensity of a powerful magnetic field, such as that in the space in which the armature-coils of a dynamo move between the poles of the field-magnets, can be determined in absolute measure; and inventors of dynamos and other experimenters in practical electricity have hitherto, at a great expense of time and money, had to construct their actual apparatus, and find by the results obtained in actual practice the efficiency or non-efficiency of their arrangements. So much so has this been the case that it has even been held that the absolute value of the intensity of a magnetic field is a thing with which practical electricians have no concern, that, although theoretically it may have some importance, it has no application in practice. That all measurements, whether of electric or of magnetic quantities, should be expressed in absolute units—that is, in units altogether independent of the locality, surroundings, and apparatus of the experimenter—is, I think, of very great importance, if these results are to be of any service to others. And it would, I feel sure, be a great benefit to all engaged in practical electrical work, if the intensities of the magnetic fields obtainable with various forms of electro-magnets, made with different kinds of iron, were determined in absolute units and published with full particulars of the apparatus. But failing the knowledge which would be derived from experiments such as these, a very great saving of time and money might be made if the inventor of a dynamo, for example, were to first make models of his magnets on a small scale, and determine the magnetic field intensities obtainable in them with different current strengths, and then to reason from the results in the model to those in the full-sized machine. The object of the present paper is to describe some methods by which the intensity of a powerful magnetic field may be determined in absolute units. The methods are wholly due to Sir William Thomson; but for the sketch of theory given below for each the details of the experimental arrangements and the results I am alone responsible.

(*a*) The first method, which is somewhat interesting theoretically, is one which was used in the determination of the magnetic field-intensities in the space in which the signal-coil is suspended in some of Sir William Thomson's syphon recorders made with permanent magnets. In it advantage is taken of the signal-coil, which consists of a rectangular coil a little more than 5 centims. long. and 2 centims. broad, made of thin wire, and supported by a silk thread above, so as to hang in a vertical plane round a rectangular core of iron, which nearly fills, but nowhere touches, the coil. To the lower end of the coil two silk threads are attached, as shown in the diagram, and are stretched against a bridge, B, by two weights resting on the inclined plane W. This bifilar arrangement gives a directive force, tending to bring the plane of the coil into parallelism with that of the bifilar threads; so



that when the coil is disturbed from that position, which is one of stable equilibrium, and then left to itself, it will, if the circuit be not closed, vibrate about the position of equilibrium with a determinate period of oscillation, with slowly diminishing range, until at last it comes to rest. But if the circuit be closed through a high resistance, the coil will come more rapidly to rest; and if we gradually diminish this resistance, deflecting the coil through the same angle and noting its subsidence at each diminution, we shall find it come more and more quickly to rest, until a resistance is obtained with which in circuit it just returns to the position of equilibrium without passing that position. When this resistance has been determined, the strength of the field can be calculated.

Let θ be the deflection of the coil from the position of equilibrium at time t, and T its period of oscillation when the circuit is not closed. We have then, neglecting the resistance of the air and other disturbances, for the equation of motion,

$$\frac{d^2\theta}{dt^2} + \frac{4\pi^2}{T^2}\theta = 0. \quad . \quad . \quad . \quad . \quad (1)$$

Let now the circuit of the coil be closed; a retarding force due to the current induced in the wire, and, if the effect of self-induction be neglected, proportional to the angular velocity, will act on the coil; and the equation of motion for this case will be of the form

$$\frac{d^2\theta}{dt^2} + k\frac{d\theta}{dt} + \frac{4\pi^2}{T^2}\theta = 0. \quad . \quad . \quad . \quad . \quad (2)$$

For let I be the mean intensity of the magnetic field over the space occupied by the coil at time t, M the electro-magnetic inertia (co-efficient of self-induction) of the circuit for

* From the *Philosophical Magazine.*

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that position of the coil, R the total resistance in the circuit, μ the moment of inertia of the coil round a vertical axis passing through its centre, L the effective length of wire in the coil (that is, the length of wire in its two vertical sides), and b the mean half-breadth of the coil. If we call N the number of lines of force which pass through the coil at time t, and γ the strength of the induced current in the coil at that instant, we have plainly

$$N = b\,IL \sin \theta - M\gamma.$$

The rate at which N increases per unit of time is, therefore,

$$\frac{dN}{dt} = b\,IL \cos \theta \frac{d\theta}{dt} + b\,L \sin \theta \frac{dI}{dt} - \frac{d}{dt}(M\gamma);$$

and if θ be small, and I be, therefore, supposed the same for every position of the coil, we have approximately

$$\frac{dN}{dt} = b\,IL \frac{d\theta}{dt} - \frac{d}{dt}(M\gamma).$$

But $\frac{dN}{dt}$ is the electromotive force due to the inductive action; hence the current γ is, by Ohm's law, given by the equation

$$\gamma = \frac{b\,IL}{R}\frac{d\theta}{dt} - \frac{1}{R}\frac{d}{dt}(M\gamma).$$

It was assumed that the second term of this expression for γ would prove negligible in comparison with the first; and this assumption was so far justified by the results of the experiments, which agreed fairly well with results obtained, for other instruments of the same pattern, by a modification of the second method described below.

The couple due to the action of the field on the current is $b\,IL\gamma$; and, therefore, on the supposition of negligible self-induction, the retardation of the angular velocity of the coil at time t is

$$k\frac{d\theta}{dt} = \frac{b^2 I^2 L^2}{\mu R}\frac{d\theta}{dt}.$$

Hence (2) becomes

$$\frac{d^2\theta}{dt^2} + \frac{b^2 I^2 L^2}{\mu R}\frac{d\theta}{dt} + \frac{4\pi^2}{T^2}\theta = 0. \quad . \quad . \quad . \quad (3)$$

The motion represented by this differential equation will be oscillatory or non-oscillatory, according as the roots of the auxiliary quadratic are imaginary or real—that is, according as $\frac{4\pi}{T} >$ or $< \frac{b^2 I^2 L^2}{\mu R}$. Hence, if R be the critical resistance at which the motion just ceases to be oscillatory, we have

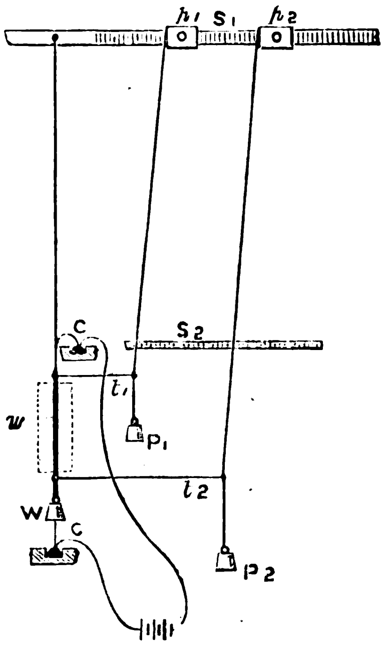
$$I^2 = \frac{4\pi R\mu}{T b^2 L^2}. \quad . \quad . \quad . \quad . \quad . \quad . \quad (4)$$

When L and b are expressed in centimetres, μ in grammes and centimetres, T in seconds, and R in centims. per second, I is given by this equation in absolute C.-G.-S. units of magnetic field-intensity.

The method of experimenting consisted in first finding the value of T, the free period of vibration of the coil with its circuit uncompleted, then finding the resistance which, being placed in circuit with the coil, just brought the needle to rest without oscillation. This resistance was conveniently obtained by means of a resistance-box included in the circuit, and therefore added no self-induction to that in the coil. An aluminium arm attached to the coil, and carrying the syphon, served as an index to render the motions of the coil visible. The resistance R was first made much too great, so as to give a slow subsidence, then gradually diminished until the value which just prevented oscillation was reached; and it was found that this value could be determined easily within 50 ohms, and, with great care, to 20 ohms. As the experiments on the recorders had to be made somewhat hurriedly, and, on account of the disturbances, neglected, and, further, as μ was taken as equal to Wb^2, where W is the mass of the coil, the results could not be taken as giving more than a rough approximation to I; but those for two instruments are given below in illustration of the method. For both instruments the values of W, L, and b were the same, and were respectively taken as 3·343 grammes, 3338 centims., and ·95 centim. Each coil had a mean vertical length of 5·3 centims., a mean breadth of 1·9 centim., and contained 45·72 metres of fine wire arranged in 290 turns, and had a resistance of about 500 ohms.

	T.	R.	I.
(1)	·465 sec.	3330×10^9 centims. per sec.	5159 C.-G.-S.
(2)	·500 „	3530×10^9 „ „	5120 „

(β) The second method is one which was adopted in measurements which I made of the fields of some experimental electro-magnets, and it depends on the action between a magnetic field and a conductor in the field carrying a constant current. The ends of the cores of the electro-magnets were long straight surfaces of iron, separated from the surface of iron placed opposite to them by only a narrow space at each pole. In the experiments, of which I give some results below, the intensity of the field was found, in a space about 2millim. wide, between one end of the iron core of an electro-magnet and the surface of a thick piece of iron. The length of the pole-face was 30 centims. The magnet and corresponding iron were placed with their faces vertical; and a copper wire was suspended vertically in the space between them, and insulated from their surfaces. The lower end of the wire dipped into a mercury cup, and its upper end into a second mercury cup on the top of the electro-magnet, with-



out touching the sides or bottoms of the cups. By means of these cups the wire could either be put in series with the coil of the electro-magnet or in circuit with an independent battery or generator. The wire was hung in a vertical position (as shown in the diagram) from the lower end of a cord about two metres long, attached to a firm support above, and was kept taut by two half pound weights (represented by the single weight W in the diagram) hung at the ends of a cross bar firmly attached to the wire. The position of the wire was adjusted by shifting the point of attachment of the cord above until the wire was exactly opposite two marks, one at the upper end and one at the lower end of the vertical central line of the pole-face. A thin thread, t_1, was attached to the wire just above the electro-magnet, and carried out to one side nearly horizontally, and attached by its other end at a point nearer the lower end of the cord of the pendulum, P_1. A second thread, t_2, was attached to the lower end of the wire, and carried out parallel to the thread t_1, and attached to a second pendulum P_2, at a somewhat greater distance from the wire. The pendulums, P_1, P_2, were simply weights, in some cases of half a pound each, and in other cases 100 grammes each, hung by fine cords from one to two metres long from blocks, p_1, p_2, which could be moved along a horizontal scale, S_1, placed nearly in a vertical plane passing through the wire at right angles to the coil of the electro-magnet, and therefore parallel to the pole-face. A

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second scale, S_2, placed just above the point of attachment of the upper thread, and nearly in the same vertical plane as S_1, gave the position at any time of a point in each of the pendulum-cords at the same distance below the point of suspension.

The method of performing an experiment was as follows:—The vertical positions of the cords of the pendulums when the threads t_1, t_2 were quite slack and the wire was in position were read off from the scales. A current was then sent through the wire and coil in series. The electro-magnetic action between the current in the wire and the magnetic field caused the wire to move bodily to one side across the lines of force; and the direction of the current in the wire was so arranged that the side towards which the wire moved was that remote from the pendulums. By moving out the blocks, p_1, p_2, pull (in consequence of the deviation of the pendulums from the vertical) was brought to bear through the threads t_1, t_2 on the upper and lower ends of the wire; and this was gradually increased until the wire was brought back as nearly as possible to its former vertical position. The readings given by the pendulums on the two scales were then taken, and at the same time a reading of the current strength on the current galvanometer. The difference between the two motions on S_1 and S_2 for either pendulum, divided by the distance between the scales, gave the tangent of the inclination of the pendulum to the vertical.

Let, now, I be the mean intensity for the position of the wire of the magnetic field in C.-G.-S. units, γ the current flowing on the wire, also in C.-G.-S., L the length of the wire in the field in centims., F the force per unit of length on the wire in dynes, we have

$$I\gamma = F.$$

But the total horizontal force exerted by the pendulums is $W_1 g \tan \theta_1 + W_2 g \tan \theta_2$, where W_1, W_2 are taken in grammes, and g, the acceleration produced by gravity, as approximately 981 centims. per second per second. Hence we have

$$I = \frac{g}{\gamma L}(W_1 \tan \theta_1 + W_2 \tan \theta_2). \quad . \quad . \quad (5)$$

From this formula the values of I can be calculated from the values of the other quantities found by experiment. The following are the results of some actual experiments made in September last:—

	W_1, in grammes.	W_2, in grammes.	γ, in C.-G.-S.	I, in C.-G.-S.	I/γ.*
(1)......	100	100	·09	2210	24555
(2)......	„	„	·132	3410	26590
(3)......	„	„	·140	4170	29785 (?)
(4)......	„	„	·156	4373	28032
(5)......	„	„	·172	4864	28283

* This column is given, as γ was also the magnetising current.

The same method was applied to find the value of I for different parts of the field on the two sides of the middle position. With two operators (one to move the pendulums, the other to watch the wire and take the galvanometer-readings) the experiments were quickly and satisfactorily performed.

(TO BE CONTINUED.)

The Telephone in Belgium.—A Central News telegram dated Brussels, August 23, says:—Some highly-interesting telephonic experiments took place here to-day, beginning at noon and lasting until ten p.m. The object was to ascertain whether, by means of a system recently devised by a Belgian engineer, the voice could be distinctly heard between Brussels and Antwerp, a distance of forty-four kilometres, or about twenty-eight English miles. The experiments were so completely successful that arrangements will be immediately made for connecting Brussels by telephone, first with Antwerp, and eventually with the most distant parts of the country.

APPARATUS FOR REGISTERING AUTOMATICALLY THE STRENGTH OF EARTH CURRENTS.*

The apparatus was designed so that by simply shunting it into the circuit of a telegraph wire a diagram of the varying intensity of the earth currents should be traced out. Owing to these currents being usually very weak, it was not possible to employ any mechanical arrangement, and recourse was had to photography. The plates used—bromide of silver gelatine plates—being excessively sensitive, all extraneous light is carefully shut out by enclosing the whole apparatus in a wooden case. The general arrangement may be seen from Fig. 1.

A bundle of rays from the lamp passes through a small aperature in a diaphragm closing the end of the tube, and,

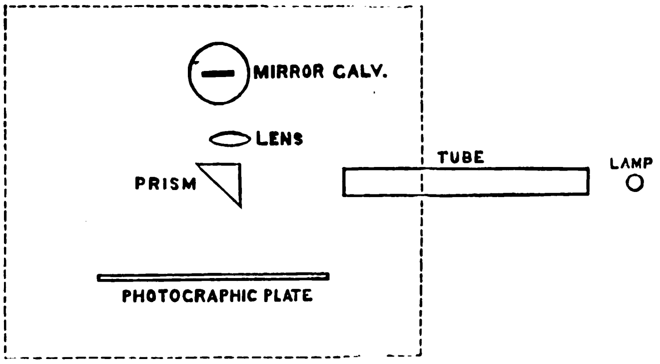

Fig. 1.

after traversing the latter, strikes a prism, from which it is reflected on the mirror of a Siemens dead-beat galvanometer. The reflected ray from the mirror is focussed by the lens on to the vertical screen supporting the gelatino-bromide plate. The plate is placed in a groove in a wooden box before beginning the observations; a screen can be slid up and down in the groove in front of the plate, as in an ordinary camera. The experimenter can introduce his hand through an opening covered by a black cloth, and can raise the slide to the top of its frame; it is then allowed to descend regularly and slowly, being controlled by a clock. In front of the slide is a horizontal slit, which allows the ray of light to pass. The descent of the slide is at the rate of about 80mm. per hour. As the

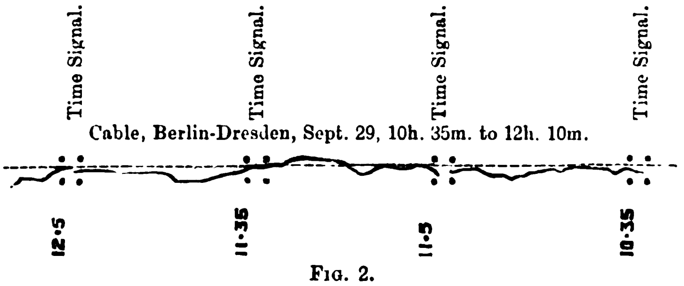

Fig. 2.

sensitive plate slowly moves downwards in front of the slit, the spot of light affects it, and the photograph will show any deflections which the mirror has made to right or left of the medial line. Time signals are given by means of the diaphragm at the front end of the tube; in this diaphragm are pierced three equidistant horizontal holes. Generally the light is allowed to pass only through the centre hole; but at fixed intervals of time (say every half-hour) the two side holes are opened, and their images then appear on the photograph on each side of the medial line. It is thus easy to measure the duration of any earth current. Fig. 2 is a facsimile of a curve traced by the apparatus, showing the earth currents on the underground cable between Berlin and Dresden on the morning of 29th September last.

* Abstract of an article from the *Zeitschrift für Instrumentenkunde*, Vol. 3, April 1883, in the *Journal of the Society of Telegraph Engineers and of Electricians*, No. 49, 1883.

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SCIENCE AND NATIONAL PROGRESS.

Recent presidential addresses by leaders of scientific research have paved the way for Dr. Gore's work on "The Scientific Basis of National Progress." In all other respects this valuable little treatise is as original as it is suggestive. Indeed, it is probably the very first attempt ever made to define both the true functions of scientific research and its effects upon the material and moral progress of a nation. It is rare that the qualifications necessary for the performance of a task like this are combined in one person; but no fault can be found with the book on the score of imperfect knowledge or want of thoroughness; and although many of its conclusions are open to question, and some of them may provoke violent opposition, the process by which they have been arrived at is logically stated, and with a profusion of illustration showing how carefully and industriously the author has studied his subject.

Taking for his motto the forward axiom that nations advance by new knowledge, Dr. Gore first seeks to establish that a nation progresses in proportion as it acquires a mastery of fresh facts. This may be called his appeal to material interests. In the next section, however, he identifies science with ethics by upholding the scientific basis for mental and moral progress. Having thus appealed to the higher as well as lower instincts of mankind, the writer fixes more exactly the relations of new truth to human progress, and concludes by advocating systematic promotion of scientific research. It would be outside our province to discuss the main questions here raised by Dr. Gore—they are well deserving of serious consideration—and we can do no more than glance at a few of the propositions dealing with the general connection between science and progress. There is no difficulty in proving this connection, though it would probably be hard to prove that it is indispensable. There are many exceptions recorded in history, and they are frankly admitted in this book; but, on the whole, the advance of scientific knowledge has generally been accompanied by material advancement, a fact which Dr. Gore conveniently formulates in the phrase "new knowledge is new power." The discovery of phosphorus, of the magnet, of electricity, of writing ink, of steam power, of gas, of photography—all these afford undeniable evidence in support of a twofold contention, namely, first, that scientific research is good of itself; secondly, that practical invention will sooner or later turn the result of scientific discoveries to useful account. Of these magnetism and electricity have played, perhaps, the most important parts, the one, by means of the compass, making the whole world known, the other, by means of the telegraph, contributing to make all peoples friendly. It is true that for many ages we derived the benefit of scientific principles without understanding them. Numerous arts and processes were extensively employed long before the principles involved in them were investigated; and in some rare instances the results of past experience have led to the discovery of scientific laws. But, in general, the reverse of this has been the case, special discoveries being more often the result of special experimental inquiry; and even in those instances of manufactures dating from remote antiquity, such as those of glass and copper, the conclusion is forced upon us that they must have been perfected, and probably discovered, by the aid of special observation intelligently directed.

The respective functions of research and invention are repeatedly referred to in the work before us; but we cannot say that they are very clearly distinguished. Perhaps, indeed, the author, like some other scientists who have spoken on the subject recently, does not wish to distinguish them, but would much prefer seeing them united. To this end the scientific education of the artisan, the practical manufacturer, or workman, is warmly advocated, in order that he may no longer blindly follow in the old trodden paths, but intelligently pursue his labours under the guidance of scientific laws. All this is now being gradually recognised by the nation, the encouragement lately given to technical education testifying to a widespread change of public opinion in this relation.

But Dr. Gore goes further than this. He would endow not only scientific education, but scientific research. We invite the readers to study the question for themselves in Dr. Gore's pages, which will afford them the best possible materials for appreciating its bearings. But we cannot help thinking he overstates the neglect into which scientific research, as such, has fallen. In reality it has not fallen either in fact or in public estimation. The author himself admits as much when he endorses the statement that this is a scientific age. The age is, indeed, pre-eminently and peculiarly scientific. Nor, in fairness, can the scientist complain of want of encouragement. He is at this moment the greatest of living powers, and when he speaks the whole world stands dumb. He is the teacher of teachers, and in spite of the non-

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scientific society which Dr. Gore refers to so disparagingly, with its annual income of two hundred thousand sterling, the scientific investigator, if he has investigated to any purpose, is master of the situation.

Neither is it so certain that he receives inadequate remuneration; inadequate, that is, compared with the rewards of other professors whose callings are more or less of a speculative kind—speculative, we of course mean in respect to their achievements. Many have died poor, and some even neglected; but that is no uncommon fate for others besides philosophers; and although this is not the age in which to underrate the value of a good income, it is hardly consistent with the view that scientists ought to labour and do labour for truth's sake, to fretfully bewail that they are not as well paid as bank managers or railway directors. Science has not yet discovered how to live on fame—an article, moreover, which is not always procurable when needed most; but for what it is worth, and in the scientists' estimation it is worth a great deal, it is given without stint and in full measure if he has earned it. Faraday—one of the examples cited—with his two hundred a year, was and will ever remain a far greater figure in the world's eye than the biggest of millionaires living or dead. Such men as he have also the satisfaction of living the life they passionately enjoy, and enjoy in a measure far exceeding that which is the share of most men, who, if they spoke the truth, would own that their wages are more of a compensation than a reward. Dr. Gore is never tired of asserting that the scientist is a searcher after truth for its own sake. The scientist, however, it should be confessed, has not a monopoly in the search, nor in the virtue of following it for its own sake, which is another way of saying he pursues it because he likes the occupation, and experiences intense satisfaction on finding what he seeks. The world becomes richer for this rare quality exemplified in its greatest thinkers and workers; and the world, we believe, would pay the debt it owes them if it could be apprised and apportioned. As things go it pays in coin when the debt is negotiable—that is to say has a money value—and in fame when it has not.

One way, perhaps, of discharging such obligations in a surer and more substantial manner would be to endow scientific research, as Dr. Gore seems to suggest. We are not so sure that the scientist would be much the gainer, pecuniarily at all events, by this arrangement; but we quite agree with him that the nation would. It is on the nation's concern with scientific research that the work we have been commenting upon mainly treats, and coming as it does at a time when we are at our wits' end to retain or recover the reputation we once had, Dr. Gore's interesting and exhaustive essay may prove a valuable help towards getting us out of our difficulties.

DEATH OF M. BUDDE, OF THE GERMAN POSTS AND TELEGRAPH DEPARTMENT.

The *Journal Télégraphique* for this month says:—"We regret to have to record the death of M. Budde, a director in the Department of Posts and Telegraphs of the German Empire, which took place at Berlin on the 3rd inst. M. Budde had held a position in the German Postal Administration since 1865. In 1875, when the death of General Major Meydam, Director-General of Telegraphs, necessitated a reconstruction of the service, Dr. Stephan, already Director-General of Posts, was made a Provisional Director-General of Telegraphs, and M. Budde, then Privy Councillor of Posts, was appointed to assist him in the direction of the Telegraph department. This provisional appointment was definitely confirmed at the end of the same year, when M. Budde was retained with the title of director of the General Telegraph Office. It was in this capacity that he took part in the international conference held at London as the first delegate of Germany. In 1880 the postal and telegraph administration having been elevated into a ministerial department, the result was a reorganisation which instituted three directorships, the second of which, that of the telegraphic service, remained in the hands of M. Budde. He held this office up to 1882, when he was chosen to replace M. Wiebe as director of the first department, namely, that of the postal service.

"The ever increasing importance of the duties which M. Budde had to fulfil in the course of a career only too suddenly cut short bears witness to the value of his services and the high esteem in which he was held by his government. Those who, like ourselves, had the opportunity at the conference in London of appreciating the eminent qualities, the practical good sense, and the lively intelligence as regards official matters which characterised M. Budde, and had caused him to become a great authority amongst his colleagues, will not wonder at this. To-day we hope to be permitted to act as their interpreter in expressing to the German Government the lively sympathy with which the Telegraphic Union regards the loss that it has just suffered, and the sorrowful regret with which it has seen disappear in succession—MM. Gumbart and Gunther, and yet another member of the brilliant delegation which this administration sent to London, and which their colleagues from other countries would have been so happy to have met again at Berlin in 1885."

VIENNA INTERNATIONAL ELECTRIC EXHIBITION.

Exhibits sent by the Society of Telegraph Engineers and Electricians.

The Council of the Society of Telegraph Engineers and Electricians have so far succeeded in their efforts to meet the British Commissioners' appeal for further exhibits as to have been enabled to despatch the following articles, viz.:—

Lent by Mr. Latimer Clark, Past President:
- Portion of original telegraph line, laid by Cooke and Wheatstone.
- Portion of first cable laid between England and France.
- Original models of dial telegraph, 1816.
- Original type cast in 1832 for the electro-magnetic telegraph by Morse.
- Portion of the original telegraph line laid by Ronalds, 1816.
- Insulators used by Morse.

Lent by Mr. W. Groves, Associate:
- Set of apparatus for illustrating Mr. Stroh's experiments on attraction and repulsion, due to vibration, and a comparison between the phonomena with those of magnetism.
- Professor Hughes's induction balance.
- Professor Hughes's sonometer.
- Professor Hughes's torsion balance.

Lent by Mr. R. Sabine, Member:
- Original Wheatstone bridge.
- Original photometer.
- Original resistance coil.

Lent by the Society:
- Original letter from the late Philipp Reis to Mr. W. Ladd, dated 13th July, 1863, describing his telephone.
- Original hand bills advertising the telegraph between Paddington and Slough, 1845.

Lent by Sir William Thomson, Past President:
- Thomson's patent azimuth compass.
- Thomson's patent sounding apparatus.
- Thomson's patent graded galvanometer for potential.
- Thomson's patent graded galvanometer for current.

There can be no doubt that, had it been decided at an earlier date that the society should collect and exhibit apparatus of scientific interest, a much greater display might have been made, but looking at the very late period at which the appeal was made to them, and that the majority of those

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likely to contribute are away, we congratulate the council upon the result of their endeavours to meet the commissioners' request.

CORRESPONDENCE.

TRANSMISSION OF POWER BY ELECTRICITY. PRACTICAL RESULTS OF M. MARCEL DEPREZ'S EXPERIMENTS.

(Translation.)

TO THE EDITOR OF THE ELECTRICIAN.

SIR: The conditions under which the experiments on the transmission of power by electricity have been made so far do not allow us to judge of the economic value of this mode of transmission.

The committees charged with the prosecution of the experiments have been careful to make known that the latter were not of a character to enable them to estimate the industrial future of the results obtained, and the inquiry in which they were engaged was more scientific than practical, although the practical and industrial side of the problem should, above all, have been considered.

It is for this reason that I have been enabled to say, in an article on this question, that the problem of the transmission of power by electricity awaited a more complete solution than that which has been given us; and that I should like to see more conclusive experiments before considering M. Marcel Deprez's system as practically satisfactory.

The reports of the *savants* who controlled the experiments devote far too much space to electrical data, and do not show with sufficient clearness what was the effective work transmitted. I willingly recognise that the electrical data are of capital importance to the specialists who have undertaken to elucidate this important question; but what we want above all to know is, whether we can hope to see transmitted to hundreds of kilometres the power required by a large works, and if this can be economically accomplished?

Now, neither the different experiments made by M. Deprez, nor the reports of the various committees, afford any certain data as to the practical results obtained by the trials. The only fact that can be affirmed is that up to the present not more than 4 horse-power has been transmitted to a relatively small distance, and that the gross return at the axle of the receiver hardly exceeded 30 per cent. It is certain that we can hardly call the amount of energy transmitted in this instance considerable, whilst the average power furnished during the experiments of the 4th March last, at the workshops of the Northern Railway, at Paris, did not even reach this figure. Again, it was necessary that the two machines should be placed a few metres distant from one another, in order that this result might be attained?

During these experiments, in fact, the generating machine, a No. 20 Deprez make, was connected to a Gramme receiving machine, type D modified, on one side by a short thick wire, perfectly insulated; and on the other by a galvanised-iron telegraph wire of 4 mm. diameter, leading to Bourget and back, and having a length of 17 kilometers.

I confess that I would have preferred to take part in an experiment in which the machines were not placed side by side, and above all in which they were not connected as above mentioned. The taking of simultaneous electrical measurements would not, perhaps, be so singularly facilitated; but the experiment would be singular, and the results less doubtful.

In point of fact, the arrangements at the Northern Railway Station differed essentially from the conditions encountered in transmitting power to a distance, by reason of this direct coupling up of the two machines. It has been well stated that, so far as the estimation of the return is concerned, a portion of the line might, without difficulty, be replaced by a short wire of an equivalent resistance; nevertheless, we have a right to raise serious objections to this mode of experimenting.

M. Hospitalier, the eminent electrician, has, however, shown that when transmission is effected with a machine placed at each end of a double line, the losses which may be brought about through imperfect insulation effect a diminution in the current which traverses the receiver, and, consequently, in the duty; whilst, when the machines are placed side by side, as was the case during the experiments, the more or less perfect insulation of the telegraph line has no effect upon the duty, and the work done increases in proportion as this insulation becomes imperfect. I will go further; I believe that it is possible, if not probable, that the results recorded during the experiments of the 4th March would have been different to what they were if the machines had been differently connected, and if, as was desired by one of the members of the committee, connection with earth could have been made at will from the wire connecting the two machines. In point of fact, as matters were arranged at the Northern Railway workshops, the experimenters considered the short thick wire as an earth connection without resistance. Now, there is nothing to prove that this insulated wire did not become the conductor of the effective current, whilst the line unexpectedly acted the part of the return wire, attributed to the thick wire. Under these conditions, evidently, the defective insulation of the line, by diminishing the resistance of the return wire, would increase the work done, and indeed it would not be necessary that shunt circuits should be formed to render the results of the experiments completely false.

I have already expressed myself as dissatisfied with the method of coupling up the machines adopted at the Northern Railway Station. This matter is touched upon in the report of the committee engaged in the experiments, in a free and easy way, which in no way diminishes its weight. To convince oneself of this, it is quite sufficient to turn to the column in the report which gives the resistance of the telegraphic conductor, to see that this resistance varied 19 per cent. below or above the average. I repeat, therefore, that a direct experiment would have been preferable to all the theoretical considerations, and to all the evidence which it has been sought to bring forward in favour of the non-influence of the method of coupling up, and I may add that this want of clearness can cause doubts in the mind, and will end sooner or later by throwing discredit on a matter which, taken as a whole, is destined to give results which might be considered as practically satisfactory.

Again, there is another point which is generally overlooked. This is the question of the specific cost price of intermediary machines and conductors; it is absolutely necessary that this price should not exceed a given amount.

This condition shows that if we suppose that the distance was of itself without effect upon the duty, as M. Deprez assures us according to his theory, there are, nevertheless, certain limits beyond which the installation could no longer be carried out from an industrial point of view. In fact, the distance evidently will step in and increase the resistance of the wire, which varies in proportion to its length, and also (inversely) as the square of its diameter. We must therefore increase this diameter as the distance to be overcome also increases; that is to say we cannot diminish or suppress the influence of distance, except by incurring a ruinous first cost.

But further, it is probable that the principle of machines wound with fine wire and telegraph wires as conductors, which served for the relatively weak currents in M. Deprez's experiments, will have to be abandoned. Up to the present they have contented themselves with high potentials, therefore they could only transmit a small amount of power. Now, against this we have the fact that the transmission and distribution of energy on a large scale requires both high potential and large currents. The fine wire, electrically prejudicial, all things being equal, will therefore gradually be replaced by thick wire, which will be in all ways excellent as far as the solution of the transmission of power problem is concerned; but hardly so as regards weight of material, distribution, and machines, and above all the first cost of an installation. On the other hand, the reports recently published seem to treat the question of the return too lightly.

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M. Cornu thus deals with it in his report to the Academy of Sciences. He says in fact that, under special conditions where the electrical transmission of power is concerned, *the question of the return is but an accessory one;* because it is generally a question of utilising forces not hitherto made use of, by reason of their distance away. Now, we have just seen that the cost price of power transmitted will depend always in great part on the amount of the first cost of an installation, and it is evidently necessary that we take account of this *detail.* The future of the electrical transmission of power will not be assured until a decent return *(rendement serieux)* is guaranteed.

Was I wrong in saying at the outset that it was impossible to give even approximately the practical results of the experiments made up till now? In the presence of such assertions as we see made in official reports it is permissible to add that these documents should only be accepted with all reserve, or that at the least it should be indispensable that those interested in the question should know in what spirit these documents were drawn up, and, above all, under what conditions the experiments were made.

The objection which I have put forward against the method of coupling up is founded not only on the view I have taken with regard to the shunt circuits which might be formed along the telegraph line, but also on the consideration that in truth the whole system may have been short-circuited owing to the part played by the short thick wire which connected the machines in the experiment room. The effect of this direct connection by an insulated conductor added to that of the short circuits (*dérivations*) mentioned by M. Hospitalier, evidently completely alter the conditions imposed upon the transmission of power to a distance, and the data supplied by the committee can have no significance of any weight whatever.

If the two ends of the 4 mm. line had been cut, and if connections with the earth had been made from the machines, it is probable that the same results would have been obtained by using the thick wire only, which would have proved the fallacious nature of the whole experiment. If to all this I add that the electricians themselves are wholly at loggerheads on the fundamental principles of the problem of the transmission of power, and that certain of them, by no means the least learned, discard as worthless the electrical results collected by the academic committee, I shall have been enabled to show that the conditions of experimenting, the method of calculating the results—all are to be regarded with suspicion. I believe, indeed, that electricity and science in general are injured by the untimely way in which this question has been raised from uncertain experimental data, and certainly the prestige of *savants* who are most justly held in honour has suffered somewhat from the scientific squabbles of these later times.

Under these conditions it would be superflous to give here the electrical measurements obtained before and during the experiments, or the method of determining the co-efficients of reduction of these measurements. Neither will I pause to consider the dynamometrical measurements for which the co-efficients of reduction had likewise to be calculated. The results thus obtained are nothing more than indirect determinations, and cannot suffice for one interested in ascertaining the practical advantages of the system, and who only looks at the industrial aspect of the question.

The only fact which it may be useful to know, is that during the later experiments the result of transmitting three horse-power to a distance which we do not know how to define, but which is certainly far less than the 8 kilometres representing the distance between the Northern Railway Station at Paris and Bourget, was a return in the shape of useful work of hardly ·331 per cent. Whatever may be said about it, I am certain that the line was not in good order throughout, and that it was not a question of transmission over a wire of 17 kilometres, equal to 2 wires of 8 kilometres, connecting the machines. It is not sufficient, in fact, to determine the resistance of the line *a priori*, and to attribute a certain amount of the work to it; for it is above all things necessary to know if this resistance is the same as that measured by difference in correcting the electrical data, and yet further if this corresponds to that which actually exists in the cable.

M. Tresca's report, nevertheless, contains some very interesting facts from a purely electrical point of view concerning the system experimented with; I would notice in particular the data referring to the quantity of work absorbed by each portion of the transmitting apparatus. It will be seen that of the 10 horse-power supplied at the source (of power) two horse-power are hopelessly lost. Here, then, as M. Tresca well says, we have a *caput mortuum* (dead head), which must be taken into account when dealing with the theory. Further, the results relating to the return at different points of the electrical system lend themselves at once to a very interesting interpretation when we ascertain that each of the three portions of the installation gives a useful effect of ·70. Under these conditions the total useful effect would be $0{\cdot}70^3$, or ·343, slightly higher than the figures ·331 which are given above.

However, the actual distance traversed by the current remains an unknown quantity.—Yours, &c.,

ALBERT BANDSEPT, 15, Chaussée de Wavre, Bruxelles.

12th Aug., '83.

SINGLING OUT A STRAND IN MULTIPLE CABLE.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In reference to Mr. Rowbotham's letter in last week's *Electrician*, I beg to state that he is not alone in reducing that arch enemy of telephone engineering to a useful agent. I have made an arrangement similar in principle to that described, and it has been in use for some time (since the summer of 1882), and with very gratifying results.

The contrivance referred to is based on the researches of Mr. A. W. Heaviside (his preliminary experiments forming the subject of a paper read before the Society of Telegraph Engineers). But instead of using a key, as done by your correspondent, a Reis transmitter, or singing telephone, was originally employed, and by this means the prime circuit was made and broken with sufficient rapidity to produce a musical note, which is much more easily detected than Morse signals.

The searching coil is of special construction, purposely to remove the return wires to a maximum distance, with a minimum resistance from the prime conductor.

At Newcastle-on-Tyne, where there is an extensive underground system, principally telephone circuits, "The Induction Wire Finder" has been of immense service in picking out wires, especially in deep buried boxes without slack, and at places where a great number of wires converge. On several occasions one wire had to be singled out of a thousand, and this has been successfully accomplished in a few minutes. The singing can be heard at some distance, and the increasing loudness facilitates and indicates the nearer approach to the required wire.

Lately an automatic make-and-break has been designed, which dispenses with the necessity for an assistant singing into the Reis telephone, a performance which in some localities occasioned great surprise and amusement to the passers by.—Yours, &c., W. K. SMITH.

EDUCATIONAL.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I hope it will not be troubling you too much to again ask you to insert the following:—

I am very grateful for the answer to my query as to the best way of getting a practical knowledge of electricity, but pecuniary circumstances put this course beyond my reach.

Can any fellow reader tell me if the classes in connection with the City and Guilds of London Institute do anything in this direction, *i.e.*, practical electricity, or electrical engineering? If not, any suggestions will be very acceptable as to what course I should take.

And also the best place for working up for next season's honours examinations. The classes I know take up elementary stages only.

Hoping I am not trespassing too much on your valuable space, I am, &c., CONSTANT READER.

66, Monnow-road, Bermondsey, Aug. 29, 1883.

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ELECTRO-MOTORS AND THEIR GOVERNMENT.*

BY PROFESSORS W. E. AYRTON, F.R.S., AND JOHN PERRY, M.E.

(CONTINUED FROM PAGE 358.)

In making experiments on motors, it is very important to be able to keep the torque constant while changes are made in the speed, in order, for example, to see exactly how for a constant torque the current varies with the speed. With the simplest form of absorption dynamometer, consisting of a cord or band passing over a pulley, and having unequal weights attached to its extremities, this is almost impossible, since, in order to keep the difference of the weights constant, it is necessary, if the co-efficient of friction between the cord and the pulley alters, to alter the smaller weight, and hence also the larger. This is easily seen from the equation

$$P - Q = Q\left(k2{\cdot}71828^{k\frac{l}{r}} - 1\right)$$

where P and Q are the two weights, k the co-efficient of friction, l the length of the cord wrapped on the pulley, of which the radius is r. Now, as even with careful lubrication it is difficult to keep k, the co-efficient of friction, perfectly constant, and as also it is difficult to arrange to increase or diminish both weights as the co-efficient alters, it follows that this simple dynamometer cannot be employed, as the cord is constantly tending to slip off on one side or the other of the pulley. If a spring balance be attached to the cord on the side on which the tension is greatest, the arrangement becomes automatically adjusting, but it does so

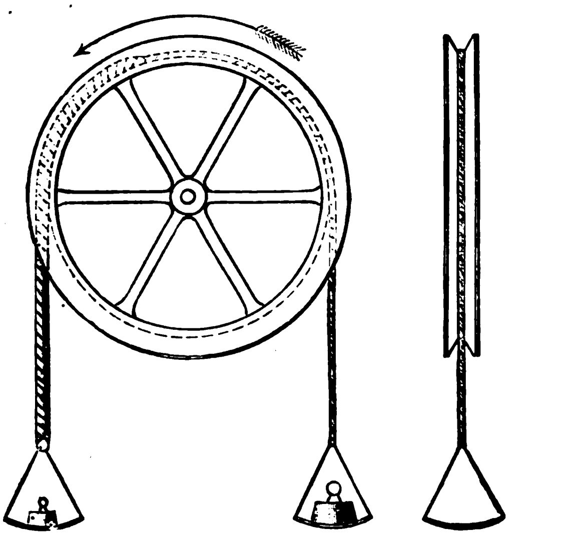

FIG. 28.—Ayrton and Perry's Compensating Dynamometer.

by P varying to suit k; hence P – Q is not a constant. The Prony brake is to a certain extent an improvement on this, because alterations in the co-efficient of friction can to a certain extent be compensated for by tightening up the screws of the brake-block by hand, without altering the weights attached to the end of the lever. The compensating dynamometers referred to above are, however, better still, since with these the length of band wrapped round the pulley is automatically adjusted as the co-efficient of friction alters. And further, the torque, which is proportional to P – Q can be increased simply by increasing P, and without altering Q, since here again l automatically changes to suit this change.

In spite, however, of these advantages, there are certain disadvantages attending the use of such a compensating dynamometer, arising from the fact that it is quite a distinct instrument from the motor, and has to be carefully coupled to the shaft of the motor, considerable precaution being necessary, even when a flexible coupling is employed, to avoid friction being introduced by a strain on the two shafts.

We have therefore set ourselves to devise some simpler form of compensating absorption dynamometer, and have arrived at excellent results by using a most simple expedient. In the Prony brake the amount of pressure between the brake and the pulley is adjusted by screwing up the tightening screws by hand, to compensate for changes in the co-efficient of friction. In the Thomson, Carpentier, and Raffard dynamometer it is the length of the band wrapped round the pulley that is automatically altered; but the plan we adopt consists in keeping the length of the cord fixed, but automatically varying the nature of the cord in contact with the pulley. Fig. 28 shows the exact arrangement we employ. On the shaft of any motor of which the power and efficiency are to be tested is keyed a grooved wheel of suitable diameter, and in the groove of this wheel is placed a cord carrying two unequal weights at its ends in the ordinary way. The two halves of the cord are of very unequal thicknesses and co-efficients of friction, the junction between the two portions being slightly tapered. The thicker and rougher part of the cord carries the smaller weight, and is therefore on the descending part of the wheel, and the compensating action, which we find to be very perfect, it is very easy to understand. If from the drying up of the lubricant, or from any other cause, the co-efficient of friction between the grooved wheel and the cord becomes greater, the larger weight is raised, and were there no adjusting arrangement it would be thrown over the wheel. But the ascending of this larger weight causes less of the rougher, and more of the smoother cord to be wrapped on the wheel. Hence the larger weight rises only far enough for this change to be effected to a sufficient degree to compensate for the increase in the co-efficient of friction. And if the co-efficient of friction diminishes, it is the larger weight which descends a certain amount, causing more of the rougher, and less of the smoother cord to be wrapped on. It is obvious that, by using a grooved wheel of sufficiently large diameter, the sum of the weights, and consequently the pressure of the motor shaft on its bearings, corresponding with any given torque, can be made as small as we like.

It was not until near the completion of this investigation in motors that we devised the new form of compensating absorption just described; hence the majority of our experiments have been made with a Raffard dynamometer. We have already explained the importance of using a flexible coupling between the shaft of this dynamometer and the motor shaft; and in the case of small motors, where the useful torque is necessarily small, the utmost care must be taken to avoid the introduction of even a small unknown resistance at this coupling, if the maximum power of the motor is to be obtained. With such small motors, we have found that a long spiral spring, with coils of comparatively small diameter, formed a very good flexible coupling.

And the same kind of spiral spring coupling we have used to connect the speed counter, or the speed indicator, with the motor, since the ordinary plan of pressing by means of the hand the speed counter or indicator against the revolving spindle of the motor is quite inadmissible when testing small motors, as the variable hand-pressure introduces a serious unknown error into the results. A speed indicator which gives the speed at any moment is the more convenient, but its calibration must not be forgotten to be made, by comparing its readings at different speeds with the results obtained with a speed counter, seeing that the majority of the speed indicators we have met with have had quite appreciable errors in the graduation. We have found it, however, quite easy to obtain very consistent readings by using a speed counter turning constantly with the motor; for although the counter is continually revolving, we find it possible, at a speed of 2,000 revolutions a minute, not to make an error of more than 6 or 7 revolutions, or only about $\frac{1}{10}$ per cent., by observing it when in motion at the beginning and end of a certain interval of time.

CONNECTION BETWEEN BACK ELECTROMOTIVE FORCE AND SPEED OF A MOTOR.

Considering the somewhat complicated way in which the fields due respectively to the armature and to the field-magnet are distorted, each by the iron core of the other, and that both fields are carried round through a certain angle by the motion, it is very striking to find even in our motors, where not merely the field-magnet field but also the armature-field is made intentionally important, that, whatever be the lead of the brushes, the back electromotive force is proportional to the speed, if the current passing through the motor be kept constant. Thus, for example, with our nomal size motor here on the table, with six positions of the brushes differing successively by fifteen degrees, we obtain as the result of a large number of experiments,

$$e = n \times 0{\cdot}01193 \text{ for } \phi = 9^\circ$$
$$e = n \times 0{\cdot}01160 \text{ „ } \phi = -6^\circ$$
$$e = n \times 0{\cdot}01110 \text{ „ } \phi = -21^\circ$$
$$e = n \times 0{\cdot}01050 \text{ „ } \phi = -36^\circ$$
$$e = n \times 0{\cdot}00901 \text{ „ } \phi = -51^\circ$$
$$e = n \times 0{\cdot}00589 \text{ „ } \phi = -66^\circ$$

where n is the number of revolutions per minute.

The e here mentioned is obtained by subtracting $C\,R_0$ from the potential difference established at the motor terminals. To obtain the true back electromotive force, v, we ought, as already explained, to subtract a term, $C\,n\,p$, in consequence of the increase

* A Paper read before the Society of Telegraph Engineers, May 10, 1883.

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of the resistance arising from the rotation. Hence, for a constant current, if e is, as we find, proportional to the speed, so ought v to be. It follows, then, that although γ increases with the speed, and although the expression previously given for the true back electromotive force increases with γ, still it is a constant for a constant value of C and ϕ. Now, for a constant current, v may be expressed as a function of n multiplied by a function of ϕ and n, or

$$f(n) \times f^1(\phi, n);$$

and v we have proved is independent of n if ϕ is constant. Hence when n is altered, $f(n)$ must vary in inverse proportion to $f^1(\phi, n)$.

If we consider the above-mentioned values of e, and divide them by n, we obtain a series of constants for each lead; or, if we plot the values of e for a fixed current and for a fixed speed, we obtain the form of $f^1(\phi, n)$, since v and e for a fixed current and a fixed speed only differ by a constant. This we have done in Fig. 29 for a speed of 2,000 revolutions per minute, in which case the following were the corresponding values of e and ϕ:—

e.	ϕ.
23·85	+ 9°
23·2	− 6
22·21	− 21
21·01	− 36
18·02	− 56
11·78	− 66

It is interesting here to notice the fact on which we have already laid great stress, namely, that a back lead, although it may cause

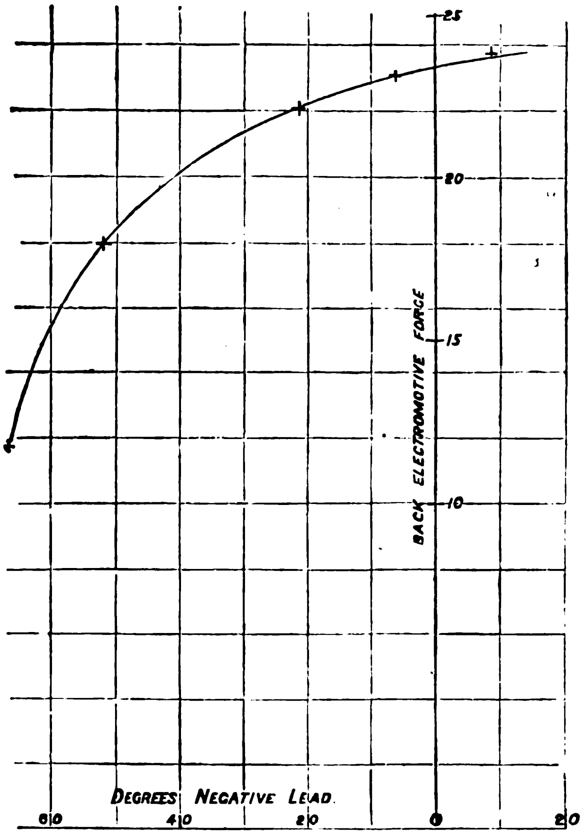

FIG. 29.

less sparking, does so at the expense of the back electromotive force, which we observe diminishes steadily as the lead becomes more and more negative.

We have already seen that

$$v = n\chi(\phi, C),$$

and

$$C\,V = C^2(R_0 + np) + C\,v;$$

also that

$$C\,v = P + n\,r + \psi,$$

where P is the power utilised, $n\,r$ the power wasted in material friction, and ψ the power wasted in magnetic friction and friction with the air. Hence the efficiency of the motor E

$$= \frac{n\,C\,\chi(\phi, C) - n\,r - \psi}{C^2(R_0 + n\,p) + n\,C\,\chi(\phi, C)},$$

so that if ϕ and C are constants

$$E = \frac{A - \frac{\psi}{n}}{\frac{B}{n} + D}.$$

But we find that, whatever the lead of the brushes may be, there is a certain speed for every lead beyond which not only does the efficiency diminish, but it diminishes proportionately to the increase of speed; that is, as soon as $\frac{B}{n}$ becomes insignificant in comparison with D, we have E following a law of the shape

$$E = a - b\,n.$$

Hence we see that ψ must be proportional to the square of n—that is, the waste of power due to magnetic friction and the friction of the air must be proportional to the square of the speed, or the frictional force is proportional to the speed, the ordinary rule for fluid friction.

The following sets of numbers obtained from experiments with one of our normal size motors, weighing 36lb., before making the improvements described further on, are examples of the results from which we have deduced the law just stated:—

PERCENTAGE EFFICIENCY AT THE FOLLOWING SPEEDS.

LEAD.	Revolutions per Minute.							
	600	800	1,000	1,200	1,400	1,600	1,800	2,000
$\phi = -66°$	25·8	29·0	29·9	30·3	29·4	28·1	26·5	24·6
$\phi = -51°$	26·2	28·6	29·5	28·6	26·6	23·4	21·4	18·0
$\phi = -36°$	24·9	26·0	26·3	25·6	24·2	22·0	18·9	14·8
$\phi = -21°$	26·2	27·1	26·0	23·6	20·8	16·2	11·6	6·0
$\phi = -\ 6°$	22·6	25·4	24·0	21·2	17·0	12·0	5·8	—
$\phi = \ 9°$	20·3	20·6	19·8	17·9	14·0	8·0	0·9	—
$\phi = \ 24°$	17·4	17·4	16·6	14·7	12·0	6·9	2·6	—
$\phi = \ 39°$	12·9	13·4	10·2	8·9	4·2	—	—	—

The two great sources of loss of power in dynamos and motors are—

1. Loss by electric resistance.

2. Loss by magnetic friction.

In small motors we find that when the first of these is great the second is small, and when the second is great the first is small. This is to be expected; for when the magnetic field for a given current is made very strong, by means of pieces of iron protruding from the armature, the motor becomes a powerful one, only a small amount of power being wasted in heat due to wire resistance. But this very protusion of pieces of iron produces necessarily discontinuity in the magnetic field, so that, although the average field set up by the armature through which the field-magnet moves is a constant relatively to the field-magnet, it undergoes fluctuations, and so causes heat in the iron of the field-magnet, in addition to the heat set up in the iron of the armature by the constant reversals of the current in it. Thus we find in our motors, where the resultant magnetic field due to the armature and field magnets is very powerful, that it is magnetic friction that we have to strive to diminish, whereas in motors made on the Gramme or Siemens principle it is the heating due to resistance that is so much in excess. Similarly in the De Meritens machine, a complete set of experiments on which is about to be given, the magnetic friction is comparatively small.

This being the case, we use these observations to illustrate how any machine may be taken up by a student, and the law for its efficiency and power determined without his binding himself down to any theory of the loss due to magnetic friction. But when taken up in this way, even the experiments on the De Meritens machine show the loss due to magnetic friction is proportional to the square of the speed.

This object alone would not have been a sufficient reason for putting before the members such a large number of results of experiments, but we give these numbers mainly because we are not aware that any such complete set of observations, so carefully made, on a motor has yet been published. And as there are many persons who are anxious to investigate this important question of motors, and who have no opportunity of making observations for themselves, it has appeared to us desirable that accurate data should be at their disposal.

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Experiments on De Meritens' Motor, Monday, 26th February, 1883, and the following days.

Speed.	Current in amps.	Pot. dif. at motor terminals in volts.	W_1	W_2	$W_1 - W_2$	H.-P. put in.	H.-P. taken out.	Efficiency E.	Resistance R_0	$\frac{V}{n}$	e	$\frac{e}{n}$
1,504	8·4	28·1	1·6	4	2·4	·318	·162	·51	—	·0186	—	—
1,796	7·5	30·4	2·4	4	1·6	·304	·129	·42	—	·0169	—	—
1,432	9·8	29·8	5	8	3	·392	·192	·49	—	·0203	—	—
1,368	10·0	29·8	6	9	3	·399	·184	·46	—	·0217	—	—
1,260	11·1	28·6	7·4	11	3·6	·428	·203	·47	—	·0226	—	—
1,290	10·2	28·6	7	10	3	·390	·173	·44	—	·0221	—	—
1,552	10·7	32·5	7	10	3	·464	·208	·45	—	·0209	—	—
1,302	12·2	31·5	8	12	4	·516	·233	·45	—	·0241	—	—
1,188	13·9	32·9	10	15	5	·614	·266	·43	—	·0267	—	—
1,208	13·9	32·2	10	15	5	·602	·271	·45	—	·0266	—	—
1,152	14·6	31·2	10	16	6	·611	·310	·51	—	·0270	—	—
1,048	15·3	30·7	10	17	7	·632	·329	·52	—	·0292	—	—
1,008	16·4	31·0	12	19	7	·681	·316	·46	—	·0307	—	—
1,030	15·0	30·5	14·2	20	5·8	·613	·268	·44	—	·0296	—	—
572	13·1	19·8	13	18	5	·349	·128	·37	—	·0363	—	—
612	12·3	19·8	14	18·2	4·2	·327	·115	·35	—	·0323	—	—
706	13·1	22·9	14	19	5	·403	·158	·39	—	·0321	—	—
932	13·9	26·4	14	19	5	·490	·209	·42	—	·0283	—	—
2,266	12·7	47·1	10	14	4	·802	·406	·51	—	·0208	—	—
2,066	14·4	46·5	11	16	5	·899	·463	·51	—	·0210	—	—
1,986	14·1	45·3	11	16	5	·855	·445	·52	—	·0228	—	—
2,006	12·3	42·2	12	16	4	·695	·359	·52	—	·0210	—	—
1,932	12·7	41·5	14	18	4	·707	·346	·49	—	·0214	—	—
1,085	10·2	23·8	10	13	3	·327	·146	·45	—	·0219	—	—
1,844	15·6	44·0	13	18	5	·916	·413	·45	—	·0238	30·9	·0168*
1,850	15·1	45·6	13	18	5	·91	·4	·44	—	·0248	32·9	·0177†
1,940	14·7	44·9	13	18	5	·883	·435	·49	—	·0231	32·5	·0167
1,820	14·7	44·7	13	18	5	·87	·39	·46	—	·0246	32·4	·0178
1,930	14·3	43·0	13	18	5	·81	·42	53	—	·0223	31·0	·0160
2,400	14·7	61·8	13	18	5	1·19	·52	·44	—	·0257	49·4	·0206
2,947	15·6	61·5	13	18	5	1·25	·64	52	—	·0208	48·4	·0164
2,904	15·6	60·9	13	18	5	1·21	·63	52	—	·0209	47·8	·0164
1,660	10·1	32·5	11	14	3	·42	·21	·51	—	·0195	24·0	·0145
1,600	10·6	32·5	11	14	3	·44	·20	·47	—	·0203	23·6	·0147
1,840	24·4	55·7	20	30	10	1·77	·804	·45	—	·0302	35·2	·0192
1,920	23·3	55·4	20	30	10	1·68	·84	50	—	·0288	35·8	·0187
1,520	23·0	47·0	20	30	10	1·41	·664	·47	—	·0309	27·7	·0182
1,520	22·9	47·0	20	30	10	1·4	·664	47	—	·0309	27·7	·0182
1,090	23·2	38·9	20	30	10	1·17	·477	·41	—	·0357	19·4	·0178
1,120	22·6	39·2	20	30	10	1·15	·49	43	—	·0352	10·2	·0180
600	22·5	30·7	20	30	10	·895	·262	29	—	·0514	11·8	·0201
580	22·5	30·4	20	30	10	·887	·254	29	—	·0524	11·5	·0198
335	22·4	24·1	20	30	10	·695	·146	21	—	·0719	5·3	·0154
330	22·5	24·4	20	30	10	·706	·145	20	—	·0739	5·5	·0169
320	22·5	24·4	20	30	10	·706	·14	20	—	·0765	5·5	·0171‡
2,412	24·2	67·3	20	30	10	2·12	1·05	·50	—	·0279	46·9	·0194‡
2,936	24·6	65·8	20	30	10	2·11	1·28	·61	—	·0258	45·1	·0154‡
2,032	24·2	63·8	20	30	10	2·01	·89	·44	—	·0313	43·5	·0213‡
2,700	25·4	71·6	20	30	10	2·38	1·18	·50	—	·0262	50·3	·0186‡
1,000	7·6	20·3	3	5	2	·198	·087	·44	—	·0203	13·9	·0139
1,000	7·5	20·0	3	5	2	·193	·087	·45	—	·0200	13·7	·0137
720	7·6	16·0	3	5	2	·154	·063	·41	—	·022	9·6	·0134
440	7·7	12·2	3	5	2	·118	·038	·33	—	·0277	5·7	·013
910	7·4	18·0	3	5	2	·169	·082	·49	—	·0191	11·8	·0125
1,200	7·8	22·3	3	5	2	·223	·105	·47	—	·0185	15·7	·0131
1,450	8·0	26·1	3	5	2	·27	·127	·47	—	·018	19·4	·0133
1,650	8·2	29·6	3	5	2	·313	·144	·46	—	·0179	22·7	·0137
1,850	8·3	33·1.	3	5	2	·358	·162	·45	—	·0178	26·1	·0141
2,200	8·6	36·8	3	5	2	·425	·197	·46	—	·0167	29·6	·0134
1,800	8·3	33·1	3	5	2	·361	·157	·44	—	·0183	26·1	·0145
2,142	8·4	36·0	3	5	2	·393	·187	·47	—	·0168	28·9	·0135
2,460	8·6	40·0	3	5	2	·447	·215	·48	—	·0162	32·8	·0133
2,656	8·8	44·1	3	5	2	·507	·231	·46	—	·0188	36·7	·0138
2,820	9·0	47·0	3	5	2	·551	·246	·45	—	·0166	39·4	·0139
3,200	9·0	50·4	3	5	2	·592	·288	·47	—	·0157	42·8	·0133
3,400	9·3	52·8	2	4	2	·641	·297	·46	—	·0158	45·1	·0132
3,500	9·3	56·2	2	4	2	·686	·306	·45	—	·0160	48·4	·0138
480	11·0	15·7	6	10	4	·230	·086	·39	—	·0327	6·6	·013
484	11·4	15·7	6	10	4	·239	·087	·37	—	·0324	6·1	·0127
795	11·5	21·4	6	10	4	·330	·142	·44	—	·0269	11·7	·0148
620	10·8	20·3	6	10	4	·294	·111	·39	—	·0327	11·2	·0181
700	11·1	20·0	6	10	4	·297	·125	·43	—	·0285	10·7	·0153
724	10·8	20·0	6	10	4	·290	·129	·45	—	·0276	10·9	·0151
1,000	10·8	23·5	6	10	4	·341	·179	·54	—	·0235	14·4	·0144
1,000	10·8	23·5	6	10	4	·341	·179	·54	—	·0235	14·4	·0144
860	10·6	21·4	6	10	4	·306	·154	·51	—	·0248	12·5	·0145
1,320	11·4	29·3	6	10	4	·447	·237	·53	—	·0222	19·7	·0149
—	32·0	27·3	—	—	—	—	—	—	·852	—	—	—
1,165	10·8	27·3	6	10	4	·395	·209	·53	—	·0234	18·2	·0156
1,400	11·4	31·0	6	10	4	·474	·250	·53	—	·0221	21·4	·0152
—	33·2	29·0	—	—	—	—	—	—	·874	—	—	—
1,560	11·4	32·8	6	10	4	·500	·280	·56	—	·021	24·5	·0154
1,575	12·3	34·8	8	12	4	·574	·282	·57	—	·0221	26·2	·0155

Speed.	Current in amps.	Pot. dif. at motor terminals in volts.	W_1	W_2	$W_1 - W_2$	H.-P. put in.	H.-P. taken out.	Efficiency E.	Resistance R_0	$\frac{V}{n}$	e	$\frac{e}{n}$
1,690	11·6	35·9	8	12	4	·561	·303	·55	—	·0212	28·3	·0167
—	15·2	12·2	—	—	—	—	—	—	—	—	—	—
1,780	11·9	38·3	8	12	4	·610	·319	·52	—	·0215	28·5	·016
1,870	12·1	37·0	8	12	4	·660	·335	·51	--	·0192	26·8	·0143
1,964	12·5	41·8	8	12	4	·697	·352	·50	—	·0218	31·3	·0159
2,064	12·5	43·8	8	12	4	·731	·37	·51	—	·0212	33·3	·0161
2,260	12·3	45·2	8	12	4	·746	·405	·54	—	·02	34·9	·0154
—	18·8	15·1	—	—	—	—	—	—	·803	—	—	—
2,356	12·3	47·3	8	12	4	·779	·422	·54	—	·02	37	·0157
2,428	12·5	49·3	8	12	4	·823	·435	·53	—	·0203	38·8	·0159
2,536	12·5	50·5	8	12	4	·843	·454	·54	—	·0199	40	·0157
2,716	12·5	52·8	8	12	4	·881	·487	·55	—	·0195	42·3	·0155
—	19·3	15·1	—	—	—	—	—	—	·782	—	—	—
2,804	12·7	55·4	8	12	4	·943	·502	·53	—	·0197	44·6	·0159
2,720	13·1	54·5	11	15	4	·958	·487	·51	—	·02	43·5	·0159
2,852	13·1	56·3	11	15	4	·989	·511	·52	—	·0197	45·3	·015
3,010	13·1	58·3	11	15	4	1·02	·539	·53	—	·0193	47·4	·015
—	12·9	9·6	—	—	—	—	—	—	·783	—	—	—
930	15·2	28·4	12	18	6	·586	·250	·43	--	·0305	15·6	·0163
710	14·8	24·4	12	18	6	·484	·191	·39	—	·0343	12·0	·0169
620	14·7	22·6	12	18	6	·444	·167	·37	—	·0364	12·3	·0199
1,120	15·6	32·2	12	18	6	·672	·3	·45	—	·0287	13·1	·0188
1,280	16·0	35·4	12	18	6	·758	·344	·45	--	·0276	13·4	·0170
1,480	16·0	38·9	12	18	6	·833	·398	·48	—	·0263	13·4	·0104
1,660	16·2	43·5	12	18	6	·946	·489	·52	—	·0274	13·6	·018
1,900	16·0	47·0	12	18	6	1·012	·51	·50	—	·025	13·5	·0176
2,112	16·0	49·9	12	18	6	1·069	·567	·53	—	·0236	13·4	·0172
2,488	16·3	55·7	12	18	6	1·217	·667	·55	—	·0223	13·7	·0168
2,532	16·4	58·6	12	18	6	1·3	·63	·52	—	·0231	44·8	·0177
—	20·6	17·1	—	—	—	—	—	—	·831	—	—	—
—	16·7	14·5	—	—	—	—	—	—	·85	—	—	—
510	18·4	23·8	15	23	8	·6	·183	·305	—	·0466	8·4	·0164
700	18·5	27·5	15	23	8	·698	·251	·359	—	·0392	12·5	·013
940	18·2	31·3	15	23	8	·77	·337	·43	—	·0322	16	·017
1,120	18·9	34·8	15	23	8	·894	·402	·45	—	·0311	18·9	·0169
1,300	18·9	38·3	15	23	8	·981	·466	·47	—	·0294	22·4	·0172
1,400	19·8	42·1	15	23	8	1·129	·502	·45	—	·03	25·5	·0182
—	24·4	19·7	—	—	—	—	—	—	·83	—	—	—
1,600	20·1	46·1	15	23	8	1·257	·574	·46	—	·0288	29·2	·0182
1,520	20·1	46·1	15	23	8	1·257	·545	·44	—	·0309	29·2	·0192
1,700	19·7	45·8	15	23	8	1·22	·61	·5	—	·0269	29·4	·017
1,670	19·7	47·3	15	23	8	1·26	·598	·47	—	·0283	30·8	·0184
1,840	19·5	49·3	15	23	8	1·3	·66	·51	—	·0267	32·9	·0179
--	22·2	18·3	—	—	—	--	—	—	·848	—	—	—
1,820	19·3	49·3	15	23	8	1·29	·653	·50	—	·0276	33·1	0181
1,950	19·3	52·8	15	23	8	1·38	·7	·51	—	·027	36·6	·0187
2,040	19·7	55·1	15	23	8	1·47	·73	·47	—	·0275	38·5	·0189
2,200	19·8	56·8	17	25	8	1·53	·79	·52	—	·0257	40·2	·0182
—	20·5	16·8	—	—	—	—	—	—	·834	—	—	—
2,240	20·9	58·6	18	26	8	1·66	·8	·46	—	·0262	41·0	·0183
2,540	20·5	62·3	18	26	8	1·73	·9	·53		·0245	45·3	·017
—	20·5	16·5	—	—	—	—	—	—	·83	—	—	—
2,200	19·8	58·0	18	26	8	1·55	·79	·51	—	·0263	41·4	·0188
2,640	19·8	62·6	18	26	8	1·674	·95	·56	—	·0248	46·0	·0174
2,600	19·8	63·2	18	26	8	1·69	·93	·55	—	·0243	46·6	·0179
—	20·5	17·1	—	—	—	—	—	—	·83	—	—	—
600	5·2	9·9	2	3	1	·07	·026	·37	—	·0166	5·5	·0092
—	12·3	10.1	—	—	--	--	—	—	·872	—	—	—
280	5·0	6·1	2	3	1	·045	·012	·274	—	·0216	1·9	·0068
620	5·0	9·9	2	3	1	·069	·027	·39	—	·0159	5·7	·0092
1,000	5·0	13·9	2	3	1	·097	·044	·45	—	·0139	9·7	·0097
1,010	5·0	13·9	2	3	1	·097	·045	·46	—	·0137	9·7	·0096
—	16·4	13·0	—	—	—	—	—	—	·831	—	—	—
1,160	5·7	17·4	3	4	1	·138	·052	·39	—	·015	12·6	·0108
1,240	5·7	17·4	3	4	1	·138	·056	·41	—	·0131	12·6	·0101
1,650	5·4	20·9	3	4	1	·151	·074	·49	—	·0128	16·4	·0099
1,440	6·1	20·9	3	4	1	·172	·064	·37	—	·0145	15·8	·0109
1,640	5·4	20·6	3	4	1	·149	·073	·49	—	·0125	16·1	·0098
—	23·9	20·3	—	—	—	—	—	—	·848	—	—	—
1,800	5·7	25·5	3	4	1	·196	·08	·41	—	·0141	20·7	·0115
1,900	5·6	24·6	3	4	1	·18	·087	·47	—	·0129	19·9	·0105§
1,900	5·6	24·6	3	4	1	·18	·087	·47	—	·0129	19·9	·0105‖
2,200	5·8	28·4	3	4	1	·228	·098	·44	—	·0129	23·5	·0107
—	30·3	25·8	—	—	—	—	—	—	·851	—	—	—
2,280	5·7	28·7	3	4	1	·220	·102	·46	—	·0125	23·9	·0105
2,500	6·1	31·9	3	4	1	·263	·112	·43	—	·0127	26·7	·0106
2,600	5·7	31·9	3	4	1	·245	·116	·47	—	·0122	27·1	·0104
2,700	5·8	35·1	3	4	1	·274	·121	·44	—	·013	30·2	·0112
2,720	5·9	35·4	3	4	1	·278	·122	·44	—	·013	30·4	·0112
—	20·5	16·2	—	—	—	—	—	—	·821	—	—	—
3,080	5·9	40·0	3	4	1	·318	·138	·44	—	·0129	35·0	·0114
—	—	—	—	—	—	—	—	—	Mean ·841	—	—	—
5,200	4·6	40·0	No	load		·246	—	—	—	·0076	36·1	·0069

* To take this speed used counter. † Now used the indicator to take the speed with. ‡ Took these with the counter. § Indicator. ‖ Counter.

Horse-power taken out = speed × ($W_1 - W_2$) × ·0000448. The diameter of the pulley was 2½ inches, and the diameter of the pulley + the thickness of the belt was 2⅝ inches, giving a mean 2·5625 inches from which the above was calculated, W_1 and W_2 being in kilogrammes. The weight of the motor was 72lb.

Remarks.—W_1, W_2, and $W_1 - W_2$ are in kilogrammes. Lead of the brushes the same throughout all the experiments.

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The first thing we proceed to find is the dependence of torque on current. It is usually assumed that for a given current the torque is independent of the speed; but in making such an assumption the error is made of neglecting magnetic friction, and of assuming that the attraction between the field-magnet and armature is constant for a given current passing round them, the effect of the rotation in first shifting the position of the poles and, secondly, in weakening the strength of the resultant magnetic field, due to the field-magnet and armature being neglected. We, on the other hand, have invariably found that as the speed increases it requires a greater and greater current to produce a given torque.

The following gives a set of results obtained when using a motor weighing 30·8lb. consisting of a Gramme armature turning between a Siemens field-magnet, the load on the dynamometer, or difference of weights, being kept quite constant at

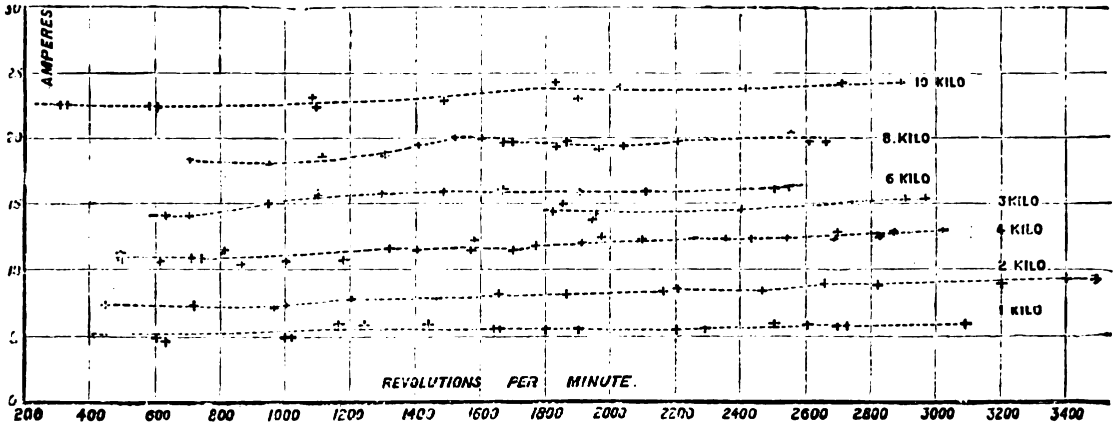

Fig. 30.

0·88lb., and which corresponded with a useful power developed of 0·1 horse-power at about 3,400 revolutions per minute:—

Number of revolutions per minute.	Current in amperes.
932	5·4
1,543	6·3
2,527	6·7
3,134	7·3
3,252	7·7
4,117	8·7

Fig. 30 shows the curves connecting currents, with speeds for various constant torques in the De Meritens motor. The increase

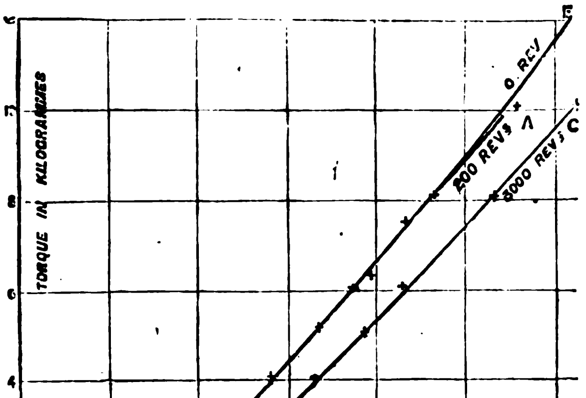

Fig. 31.

of current with speed is not nearly so great as in the case of the previous motor, but it is quite observable, and the curves are very interesting, as they enable us to calculate for the particular motor the current necessary to produce any particular torque at any speed. Thus, taking these measurements for speeds of 200 and of 3,000 revolutions per minute, we obtain the two sets of points shown in Fig. 31, evidently lying in the curves A B and C D. If T_{200} is the torque produced by a given current, C, when the speed is 200, and T_{3000} the torque produced by the same current when the speed is 3,000 revolutions per minute, we have found that $T_{200} - T_{3000}$ divided by C is nearly constant for all values of C employed, and that the difference also seems to be proportional to the difference of speeds when other speeds are taken. Hence we arrive at the conclusion that in proper units the diminution in torque for a given current is

$$\cdot 00000096\, n\, C.$$

Drawing, now, from this, the imaginary curve for no speed, and shown in E B, Fig. 31, we find that this curve satisfies the rational law,

$$T_0 = \frac{0 \cdot 002\, C^2}{1 + 0 \cdot 08\, C},$$

T_0 being the torque for a speed 0. So that for any other speed, n, we have

$$T = \frac{0 \cdot 002\, C^2}{1 + 0 \cdot 08\, C} - 0 \cdot 00000096\, n\, C.$$

It will be observed that in these experiments the friction of the

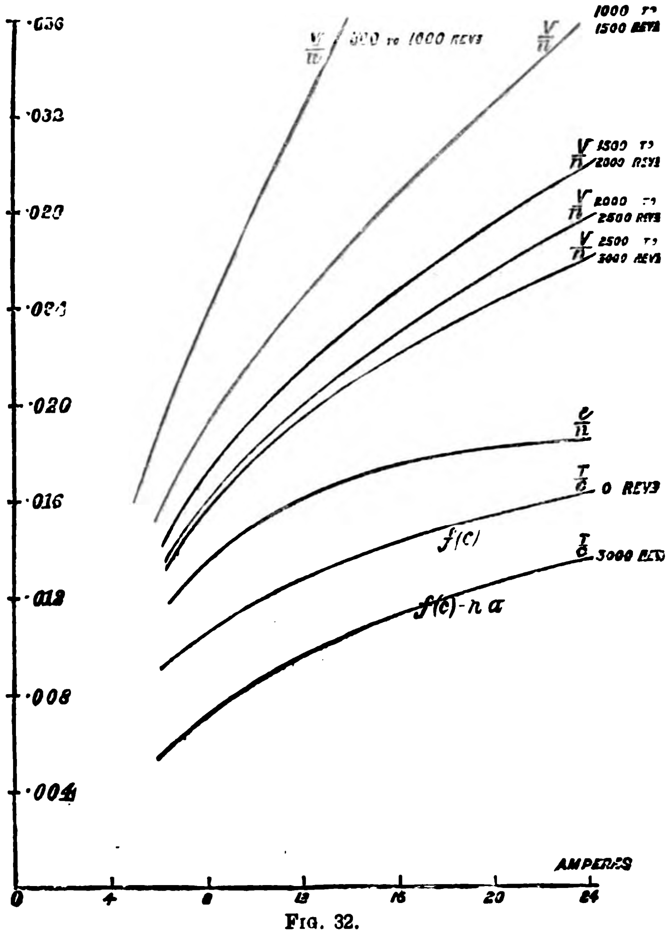

Fig. 32.

bearings of the motor and dynamometer is neglected, both being small.

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Instead of using the above numbers, we shall say

$$T = C f(C) - a n C,$$

so that

$$\frac{T}{C} = f(C) - a n.$$

In Fig. 32 we have plotted $f(C)$, which is the value of $\frac{T}{C}$, for n equals nought. We have also plotted $\frac{T}{C}$ for a speed of 3,000 revolutions per minute, and for a speed 0. The efficiency of the motor is, as already stated, $\frac{T n}{C V}$ or $\frac{T}{C} \div \frac{V}{n}$. In Fig. 32 there are drawn the curves for $\frac{V}{n}$, corresponding with various speeds. Now, if we imagine a set of curves drawn for $\frac{T}{C}$, for the various speeds (all of which, for speeds between 0 and 3,000 revolutions a minute, will of course be between those drawn for $\frac{T}{C}$ for n equal 0, and for n equal 3,000 respectively), then if two corresponding curves for $\frac{T}{C}$ and for $\frac{V}{n}$ be drawn for the same speed, the ordinate of the first curve divided by the larger ordinate of the second curve for the same current will give the efficiency of the motor for that speed and current. An examination of the curves shows that for great speeds there does not seem to be much variation in the efficiency, if we vary the speed while keeping the current constant, whereas at lower speeds the efficiency is much diminished by further diminishing the speed.

(TO BE CONTINUED.)

PRACTICAL TELEPHONY.

(CONCLUDED FROM PAGE 323.)

ADJUSTING ANNUNCIATORS.—Owing to the very feeble current that traverses the coils when there is a considerable length of line wire connected, it is necessary that the adjustment be as delicate as possible, consistent with the shutter remaining locked when subjected to the jar caused in working the "board."

See that the locking parts are in good order, and that they do not lock too deeply, as in this case the armature may be so far removed from the poles of the electro-magnet that the current will be unable to attract it and release the shutter; the locking should be so adjusted that when the armature is attracted to the magnet the shutter will be just released.

As exchanges are at present worked, it is necessary that the resistance of the annunciator coils be as low as possible, as they are included in the circuit when speaking is being carried on, and if the communication is through several exchanges, the added resistance is considerable, and the damping effect on the conversation when carried on through electro-magnets is far in excess of that due to the resistance alone.

COMPARATIVE EFFICIENCY OF SLIPPER BOARD AND SWITCH PLUG SYSTEM.—If properly worked the plug system would probably be found the best in busy exchanges, as no faults can occur from broken jack cords, and each operator has only a limited number of subscribers to attend to. Faults, however, will occur from the plugs not being pressed firmly into contact with the strips; this is particularly the case with the "earth" strip, the plugs being then in their normal position connecting the various lines to "earth." In most cases it will be found that, by running the finger lightly along under the plugs, several will drop out, owing to their not having been properly pressed home, thus giving rise to complaints of "inattention at exchange," "line dead," &c., and when the faults are searched for are probably "off." With the plug system in large exchanges the connections between the various boards become complicated, and the constant calling out of the instructions for connection becomes confusing.

With the slipper board system the board operator can attend to a large number of subscribers, so that the connection can mostly be made at once and with certainty of good contact, provided the table and jack cords are in good order; and this is really the weak point of the system, as in the cords at present in use the want of continuity cannot be readily detected, and if a cord can be devised that will come asunder or show plainly that the conductor is damaged it will prove of great value. At present attention has been particularly directed to making the cords flexible, but the more flexible they are the more difficult it is to detect a fault in the conductor.

Although great advances have been made in the apparatus and working of exchanges, it is quite probable that the present system will be short lived, as with the extension of telephony many of the faults now occurring and easily dealt with would become intolerable.

Among the changes that may be looked for are—

Total abolition of batteries for "ringing up."

Improved battery for transmitter.

Self-cleaning contacts.

The annunciators out of circuit when speaking is being carried on.

A far more sensitive annunciator than any at present in use, so that the "ring off" signal will be received through any reasonable number of exchanges.

A system of conduits to contain the wires by the means of which subscribers can be connected with least inconvenience to the traffic and cost to the company providing the service.

TECHNICAL TERMS IN ORDINARY USE.

BEING CUT OFF.—The line being disconnected at the switch room before the subscribers communicating have finished.

CANNOT GET.—Used when the exchange cannot call a subscriber's attention.

CIRCUIT.—The wires, instruments, battery, &c., forming the path for the current.

CONTACT.—Two or more wires touching each other.

DEFLECTION.—The angle, or number of degrees through which the galvanometer needle moves during the passage of a current.

EARTH CONNECTION.—The wire leading and joined to the gas or water mains to complete the circuit.

EARTH CURRENTS.—The spontaneous currents in wires, caused by currents flowing from one part of the earth to another.

FAULT.—Any interruption in the circuit by which some of the operations are interfered with.

INSULATED.—A fault or disconnection in the circuit which prevents any current passing.

LINE.—The wire connecting one station with another.

LINE BATTERY.—The battery from which ringing currents are sent out to line.

LOCAL BATTERY.—The cell or cells used to work the transmitter; or, in some cases, a bell.

LOCAL CIRCUIT.—The circuit which includes the local battery, carbon transmitter, induction coil, and connections, and which does not leave the office. In cases where a relay is used the bell also forms part of a second local circuit.

METALLIC CIRCUIT.—When a return wire is used instead of earth.

O. K.—Used in reporting a line or instruments in good order after removing a fault.

TERMINALS.—The screws of instruments, batteries, &c., to which the wires are connected.

TO CONNECT UP.—To join together or replace a wire that had been disconnected. To join up a set of instruments.

TO DISCONNECT.—To take a wire from its terminal so as to break the circuit.

TO LOOP TWO WIRES.—To disconnect them from their ordinary places and join them together. This is the operation by means of which exchange subscribers are brought into communication.

TO MAKE "EARTH."—To be connected to earth.

TO PUT THROUGH.—To connect two subscribers' lines together.

TO REVERSE A BATTERY.—To change the connections so as to reverse the current in a circuit.

TO REVERSE A CURRENT.—To change its direction.

TO RING OFF.—To signal the exchange after the communication with another subscriber is finished.

TO SHORT CIRCUIT A CELL.—To join together the terminals on each side of the faulty cell by a piece of wire.

TO SHORT CIRCUIT AN INSTRUMENT.—To join together the "line" and "earth" terminals by a piece of wire.

TRUNK.—A connecting line or lines between two exchanges or switch rooms.

TELEPHONIC TRANSMISSION OF MUSIC.—The following extract from the French journal, *L'Electricien*, of Sept. 15, 1882, will be found interesting, from the number of persons that were enabled to listen to a band at the Hippodrome, only one wire being used for the purpose:—"An interesting experiment," says M. Niaudet, "was carried out a few days since between the circus (Hippodrome) and the offices of the International Telephone Company, at 15, Place Vendome, Paris. The band at the circus, which plays in the daytime and the evening for the two daily performances, was listened to by a number of persons invited for the occasion to the Place Vendome. There were 96 telephonic receivers. Each auditor having two, 48 people could listen at the same time. We propose to give some details of the arrangements made by Dr. J. Moser to obtain this result. Through the kind-

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ness of the officials of the circus and those of the Société Générale des Téléphones, two wires which are in regular use by the circus management, who are subscribers to the exchange, were able to be used. But of these two wires, one was required for carrying on conversation, giving orders, &c., all of which are indispensable for the effective carrying out of an experiment like this between two distant points. There remained, therefore, but one wire for transmitting music by. The apparatus in the circus was thus arranged:—There were twenty-five microphonic transmitters mounted on a plank, slightly inclined from the horizontal and above the conductor of the band. The microphones were, of course, above the plank, protected from the dust by a light box. The plank itself was hung by four cords. The microphone battery was composed of three Reynier-Faure accumulators at first; the intensity of the current was indicated by a Deprez galvanometer placed in the circuit; it was kept constant by adding to these three accumulators another, then another, until the total number employed was nine. The result probably would have been obtained equally well with five Daniell cells, Reynier type, which have a very small resistance and are absolutely constant. The current is shunted through the microphones and then the 24 primary wires of 24 induction coils, connected in two series and 12 in a shunt. The intensity of the current was about 12 amperes. The 24 secondary circuits of the induction coils were grouped in series of four and six in a shunt. The resistance of each was 300 ohms, or together 1,200 ohms. The line from the circus, 3,512 metres long (about 2⅛ miles), ran into No. 66, Rue des Petits Champs, one of the offices of the Société Générale des Téléphones, where also the Place Vendome line was run to, this latter being very short. Communication was established by switches in the Rue des Petits Champs. The receivers, which were Ader's, were grouped sixteen in series and six in a shunt. The reception was perfectly clear and satisfactory to the auditors, both of the midday performance and that in the evening. We do not think that it can be denied that the above is an improvement on the method of arranging the instruments adopted between the Opera House and the Palais de l'Industrie during the Electric Exhibition of 1881. At the one end there were ten microphones, and at the other eighty receivers; but only one half of the receivers were in use at the same time; there were thus, in fact, four receivers per microphone with two wires, or twenty wires in all. The reduction in the number of the wires facilitates the process of laying them, diminishes the cost of the whole, and thus allows of more extended operations. M. Moser's experiment was made with a single wire, because the second was in use; but we do not pretend that in other cases only one wire need be employed; on the contrary, we think that it will generally be convenient to utilise two wires to avoid induction noises. We may say that the principal novelty in M. Moser's arrangement consisted in the combination in a shunt circuit of the twenty-five microphones, in the combination of the twenty-four secondary wires of the induction coils in series and quantity, as is done with the cells of a battery."

A HISTORY OF ELECTRIC TELEGRAPHY TO THE YEAR 1837.

BY J. J. FAHIE, MEMB. SOC. TEL. ENGS. AND ELECS.*

Chapter III.—Telegraphs Based on Static, or Frictional, Electricity.

(CONTINUED FROM PAGE 347.)

1802. Alexandre's Telegraph.

Twenty-five years ago, in the course of a research amongst the imperial archives at Paris, M. Edouard Gerspach, of the French Telegraph Administration, discovered some documents which, in our eyes, are of exceeding value, as establishing for La Belle France the honour of the invention of the first step-by-step, or A.B.C., telegraph. These papers were embodied by M. Gerspach in a memoir for the *Annales Télégraphiques* for March-April, 1859, pp. 188-99, to which we are indebted for much of what follows in this article.

Jean Alexandre was born at Paris, the natural son, it is said, of Jean-Jacques Rousseau. He had the education of a mechanic, some say of a physician, but his actual career was truly a faithful image of the troublous times in which he lived. In 1787 he was at Poitiers, following the trade of gilder, and, as he had a fine voice, he sang in the churches, which added somewhat to his slender emoluments. But soon the revolution came to Poitiers, and swept away the *clientèle* of the poor gilder and carver. He went to Paris, and there maintained himself for a while by singing in the choir of St. Sulpice; but the revolutionary tide followed him, and closed the doors of St. Sulpice, as of all the other churches, leaving Alexandre high and dry again, without the means of subsistence.

Feeling there was nothing else to be done, he now took to politics, and, after the manner of the times, soon found himself president of a section of the Luxembourg (club), and, later on, a deputy of the Convention. This latter honour, however, his simple manners made him decline. But greater still were yet in store, and, as he was preparing to return to his workshop at Poitiers, the Government sent him thither, but with the exalted rank of Commissary-General of War. Later on, he was promoted to be chief of the military division of Lyons, where he had to organise an army of 80,000 men. With the title of Chief Agent of the Army of the West, he next went to Angers, where, from the forty-two departments that were under his orders, he had to raise another army of 200,000 men. With all this greatness, he still was not happy; he yearned for a quiet life—a feeling which seems to have grown daily stronger with him, until, at last becoming irresistible, he quitted honours and politics, and returned to his home at Poitiers, as poor as he had left it—a fact, by the way, which speaks volumes for the integrity of his character.

Here we find him, in 1802, producing his *télégraphe intime*, or secret telegraph. He wrote to Chaptal, Minister of the Interior, acquainting him briefly with the discovery, and asking assistance to enable him to go to Paris, and exhibit his machine to the Government. The Minister asked (and naturally), in the first place, for full particulars and plans of the apparatus, but Alexandre declined to divulge his secret, and addressed himself next to Cochon, Prefect of Vienne, offering to make an experiment before him. The Prefect, agreeably impressed with the conversation of the inventor, whose quick and vigorous imagination he found to contrast singularly with the simplicity of his demeanour, granted his request, and accordingly, on the 13th Brumaire, year X (early in 1802), he went, accompanied by the chief engineer of the department, to Alexandre's house. The experiments were crowned with unhoped-for success, and the Prefect drew up a report for the minister, Chaptal, of which the following is the substance:—

"We were conducted into a room on the ground floor, in the centre of which we found a box nearly 1 5 metre high, and about 30 centimetres broad and deep. This box was surmounted by a dial, around which were traced all the letters of the alphabet. A well-poised needle, or pointer, travelled round the circle at the will of a distant and invisible agent, and stopped over such letters as composed the words that he wished to communicate. The completion of each word and phrase was indicated by an entire revolution of the pointer, which, in its normal state of rest, always occupied a certain determined position [corresponding, no doubt, to our zero].

"A correspondence was established between the [distant] agent and ourselves, and the success was all that we could desire. The dial repeated exactly all the phrases that we had dictated, and the [distant] agent added some from himself, which we had no difficulty in understanding. On asking why the second box was situated in an upper story, about 15 metres distant, instead of being placed on the same level as the first, the inventor replied that it was to show that difference of level had no effect on its action, and that the conductors could in every case go up and down, and adapt themselves to the inequalities of the ground.

"We understood, without, however, his distinctly saying so, that the author derives his power (*usage*) from some fluid, either electric or magnetic. He told us that, in the course of experiment, he had met with a strange matter, or power (of which, until then, he had been ignorant) which, he was almost tempted to believe, is generally diffused, and forms, in some sort, the soul of the universe; that he had discovered the means of utilising the effects of this power, so as to make them conduce to the success of his machine; and that he was certain of being able to propagate them with the celerity of light, and to any distance that may be required."

In concluding this report on the invention, which the Prefect characterised as a work of genius, he urged that Alexandre should be called to Paris, at the expense of the State, in order that he may repeat his experiments under the eyes of the Government. The minister, Chaptal, did not, however, regard the discovery at all so favourably, evidently imagining it to be a telegraph of the Chappe, or semaphore kind, and wrote to the inventor's agent, declining to have anything to do with him. Such a rebuff would have acted as a *quietus* to ordinary people; but inventors are proverbially a tenacious race. Alexandre was an inventor, and, firm in his convictions, he quitted Poitiers, and in hopes of better fortune, betook himself to Tours.

There, at his invitation, General Pommereul, Prefect of the

* The author reserves all rights of translation.

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Department of the Indre and Loire, and the mayor and officers of the city of Tours, assembled at his house to assist at a public trial of the apparatus. As before, one of the machines was on the ground floor, and the other on the first story, separated from the lower room by an antechamber and a small court. The Prefect dictated the phrase, "Genius knows no limits," which was transmitted to the distant end, and thence returned with all the success imaginable. The next phrase, "There are no longer miracles," was repeated with the same result, and many others followed, in which all the words were reproduced by the machines, letter for letter, with the greatest exactness.*

All these experiments, conclusive as they were, had, nevertheless, little effect in advancing Alexandre's interests; they drew on him the commendations of the multitude, made his name known, but contributed nothing towards the attainment of his end, which was Paris, and the patronage of the First Consul, to whom only would he confide his secret. Having no money for the further prosecution of his plans, he now entered into partnership with a M. Beauvais, who was to supply all sums necessary, and to receive in return a quarter of the profits of the enterprise, Alexandre keeping to himself the secret of his invention until he had netted 60,000 francs by its exploitation, after which it was to become joint property. No sooner were these terms concluded than Beauvais, provided with the official accounts of the experiments at Poitiers and Tours, addressed himself to Napoleon, and solicited the honour of a trial in his apartments, and in his presence alone. Napoleon, perhaps smelling gunpowder, declined the meeting, but referred the papers to Delambre, the illustrious academician and astronomer, who, some weeks later, returned a report of which the following is a free translation :—

"Report of Citizen Delambre on the Secret Telegraph of Citizen Alexandre, submitted to the First Consul by Citizen Beauvais :—

"The papers which the First Consul has caused me to examine do not contain sufficient details to enable me to form an opinion, nor, after the two interviews which I have had with Citizen Beauvais, am I able to do more than offer the merest conjectures on the advantages and disadvantages of the Secret Telegraph.

"Citizen Beauvais knows the secret of Citizen Alexandre, but he has promised to impart it to no one but the First Consul himself. This circumstance must make any report from me valueless, for how can one judge of a machine which one has neither seen nor understands?

"All that we know is that this telegraph is composed of two similar boxes, each having a dial, round whose face are marked all the letters of the alphabet. By means of a winch, or handle, the pointer of one dial is moved to any desired letter, or letters, and, at the same instant, the pointer of the other dial repeats the same movements, and in exactly the same order. When these two boxes are placed in two separate apartments, two persons can write and reply without seeing each other, and without being seen, and in such a way that no one can doubt the correspondence, which, moreover, can be carried on at any time, as neither night nor fogs can intercept the transmission.

"By means of this telegraph the governor of a besieged place could carry on a secret and continuous correspondence with a person four or five leagues distant, or even at any distance, and communication can be established between the two boxes as readily as one can hang a bell (*qu'on poserait un mouvement de sonnette*).

"The inventor carried out two experiments with his machines at Poitiers and at Tours, in presence of the prefects and mayors of the respective places, and the official reports of these functionaries attest that the results were completely successful. Now, the inventor and his associate ask, either that the First Consul will be pleased to permit of one of the boxes being placed in his apartment, and the other in that of the Consul Cambacérès, so as to give to their experiments all the *éclat* and authenticity possible; or, that he will accord an audience of ten minutes to Citizen Beauvais, who will then communicate to him the secret (of the telegraph), which is so simple that the bare description will be equivalent to a practical demonstration. They add that the idea is so natural as to leave little room to fear that it will ever occur to any *savant*. It is said, however, that Citizen Montgolfier divined it, after some hours' reflection, on a description of the apparatus which was given to him.

"After this statement, which is the substance of my conversations with Citizen Beauvais, a very few remarks must suffice. If, as one would be inclined to believe from the comparison with bell-hanging, the means employed comprised wheels, levers, and such like,* the invention would not be very surprising, and one could easily imagine the practical difficulties that would be encountered as soon as it was attempted to employ it over distances of several leagues.

"If, on the contrary, as the official report from Poitiers seems to show, the means of communication is a fluid, the inventor deserves much more credit for having discovered how to utilise it so as to produce, at any distance, effects so regular and so unfailing. But then, one may demand, what guarantee have we for these effects? Neither the experiments at Poitiers, nor those at Tours, in which the distance was only a few metres, supply it. No more would the proposed experiment between the chambers of the First and Second Consuls. So long as the motive power remains a secret, one can never vouch for more than what one sees, and it will be entirely wrong to conclude, from the success of an experiment on a small scale, that like results will be obtained over more considerable distances. If the effect is only attainable at a distance of some few metres the machine ought to be sent to the scientific toy shops.

"If Citizen Beauvais, who offers to defray the expenses of an experiment, had proposed to carry it out in presence of commissioners appointed for the purpose, there could be no objection to granting his request; for, although an experiment on a small scale would not be very conclusive, still it would enable us to see what might be hoped from a trial of a grander and more expensive kind. But Citizen Beauvais, without expressly declining a commission, desires, in the first place, to secure the testimony and approbation of the First Consul. It only remains, then, for the First Consul to say whether, in view of the little chance of success attaching to an invention so little proved, and announced as so marvellous, he will spare a few moments for the examination of a discovery of an artist, who is described as one as full of genius as he is devoid of scientific learning and of fortune.

"He makes a secret of his discovery, and I ought to judge it with severity, and according to the laws of probability; but the limits of the probable are not those of the possible, and Citizen Alexandre must be sure of his facts, since he offers to expose all to the First Consul. It, therefore, only remains for me to hope that the First Conzul will grant him an audience, and that, in the sequel, he will have reason to welcome the inventor, and recompense worthily the author. "DELAMBRE.

"Paris, 10 Fructidor, an X."

With this most interesting document ends the story of the *Secret Telegraph*. In 1803 Alexandre was at Bordeaux, taking out a patent for a machine for filtering the water of the Garonne for supplying the city: but, although the authorities seem to have afforded him every facility towards the accomplishment of his scheme, it was never carried out, through want of money. We next hear of him in 1831, when he submitted to the King, Louis Philippe, a project for steering balloons. He died soon after at Angoulême, leaving a widow, who died in 1833, at Poitiers, in extreme want.

Such is the sad story, as told by M. Gerspach, of one who must be regarded as a veritable pioneer in electric telegraphy; for, although Alexandre chose to surround his invention with an air of mystery, and preserved only too faithfully the secret of its action, we believe that he had, in effect, constructed a telegraph of the A, B, C sort, with static electricity as his motive power.

Some writers, however, regard his apparatus, like that of Comus, as only another instance of the sympathetic needle telegraph, and seek to explain its action somewhat after the manner figured and described by Guyot.† But there seems to us to be two very good reasons against this theory: first, the impossibility of carrying out any such piece of deception in the apartments of the two consuls; and second, the character of Napoleon, who, as all the world knows, was not a man to be trifled with.

The suspicion of Delambre, that it partook of the nature of a mechanical telegraph, we consider equally disproved by the words of the *procès verbal* from Poitiers. "He told us that, in the course of experiment, he had met with a strange matter, or power (of which, until then, he had been ignorant), which, he was almost tempted to believe, is generally diffused, and forms in some sort the soul of the universe; that he had discovered the means of utilising the effects of this power, so as to make them conduce to the success of his machine; and that he was certain of being able to propagate them with the celerity of light, and to any distance that may be required." Surely a mechanician

* The *English Chronicle* newspaper of June 19-22, 1802, has a short account of these experiments, concluding as follows:—"The art or mechanism by which this is effected is unknown, but the inventor says that he can extend it to the distance of four or five leagues, even though a river should be interposed." There is a copy, probably unique, in Mr. Latimer Clark's library.

* Forming, in fact, a kind of mechanical telegraph like the railway semaphores of to-day.

† "Nouvelles Récréations Physiques et Marthématiques," Paris 1769, Vol. 1, page 134. M. Aug. Gueront is the latest exponent of this theory. See *La Lumière Electrique* for March 3, 1883.

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would not speak thus of a combination of ropes, wheels, and pulleys. Although, once upon a time, Archimedes glorified the power of the lever, when he said that by its means he could move the world, no Archimedes of our day would be so extravagant as to call the same power, mighty as it is, the soul of the universe.

On the other hand, the language just quoted would apply very well to electricity. Thales called it a spirit, Otto Guericke thought it controlled the revolution of the moon round the earth, and Stephen Gray that of the planets round the sun; Franklin showed its identity with lightning; John Wesley regarded it as an universal healer; and Galvani had just confounded it with life. Well, then, might Alexandre be excused for calling it the soul of the universe. Again, let us recollect that while he was still a young man the invention of the Chappe semaphore, and its wonderful performances, were the theme of daily conversation; and that rival plans were being frequently started—some, semaphores more or less like Chappe's, and for night as well as day service; some, based on the properties of acoustics, as those of Gauthey and Count Rumford; and some again, as we have seen in these pages, on those of electricity.* What more natural, then, that Alexandre, a clever mechanician, and a man of a quick and vigorous imagination, should invent an electric telegraph.

Now, let us regard the apparatus as described by M. Cochon, in connection with the half admission that electricity was its basis, and that it was operated by a winch, or handle, as mentioned by Delambre. Do not this handle, the box, the dial on the top, and the conductor recall the telegraph of Lomond, which was the wonder of Paris in 1787, and which has been already described in these pages. The dial of Alexandre, it is true, is an immense improvement on the pith-ball indicator of Lomond, but that, too, had its prototype in the synchronous clockwork dial with which Chappe essayed an electric telegraph in 1790, and which, no doubt, was equally well known as the machine of Lomond. Indeed, the inference to us seems irresistible, that Alexandre took Lomond's and Chappe's contrivances as his basis, and built upon them his own improvements.

The only point that remains for consideration is, how did the working (? revolving) of the handle actuate the pointers? The explanation to our mind is not far to seek. Given an electrical machine inside the box, and a train of wheels behind the dial, and in gear with the pointer, and it would be easy for a clever mechanician to make the repulsion of a sort of pith-ball electrometer (acting also as a pawl) against a discharging surface, and its subsequent collapse, give motion of a step-by-step character to the wheels, and, through them, to the pointer. The prime conductors of both machines would, under our supposition, be connected by a wire (probably concealed from view), and thus the movements of one pointer would be synchronous with those of the other.

Some writers, as Cézanne (*Le Cable Transatlantique*, Paris, 1867, p. 32), and Berio *Ephemerides of the Lecture Society*, Genoa, 1872, p. 645), think it likely that Alexandre used the electricity of the pile, then newly discovered by Volta; but this is highly improbable, for, except in the form of the dry-pile, or through the intermedium of electro-magnetism, both of which were not then known, any number of cells that he could enclose in the box would be entirely inadequate to the observed effects. The use of a handle is as fatal to such an assumption, as it is favourable to that of an electrical machine being the *primum mobile*.

(TO BE CONTINUED.)

AN ELECTRICALLY-LIGHTED CAB.—An enterprising cabman in Vienna has lighted his cab by means of an incandescent lamp. A dynamo attached o the axle generates current when the cab is running, which is stored in accumulators and used as required.

ANOTHER DECISION AGAINST SAWYER AND MANN.—In the patent interference case of Weston against Sawyer and Mann, of New York, involving priority of invention for improvement in the art of manufacturing carbon conductors for incandescent lamps, the examiner of interferences on August 3rd rendered a decision awarding the priority of invention to Weston. The attention of the Commissioner of Patents is called to the fact that the record shows a public use of the invention by both Weston and his opponents for more than two years prior to the filing of the former's application. It is probable that this may act as a statutory bar to granting a patent to Weston.—*Electrical World*.

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* We may here refer to a remark of Amyot's, for which we have not been able to find room before, to the effect that, somewhere about 1798, Henry Monton Berton, the distinguished French composer, conceived the idea of an electric telegraph (*Note historique sur le Télégraphe Electrique*, in the *Comptes Rendus*, for July 9, 1838). This *note* is reprinted *in extenso* in Julia de Fontenel 's "Manuel de l'Electricite," but in neither case are any details given.

THE LONDON AND PROVINCIAL ELECTRIC LIGHT AND POWER COMPANY (LIMITED).

The half-yearly general meeting of this Company was held on Thursday, at the Cannon-street Hotel, Mr. J. Dunham Massey in the chair.

Mr. REDWOOD (the Secretary) read the notice convening the meeting, and the report of the directors was taken as read.

At the commencement of the proceedings several shareholders expressed their disappointment at not having received notice of the meeting, to which the secretary replied that it was called by advertisement as provided, he believed, by Act of Parliament.

The CHAIRMAN said that he had a telegram from the chairman of the Company, who was in Ireland, and could not possibly return in time for the meeting. The vice-chairman was dangerously ill, and on these grounds he was called upon to preside. The history of this Company would be found to be very similar to that of all other electric lighting companies. The facts connected with the career of all similar undertakings were no doubt well known to them all, and their position he presumed was the same as that of others. They had gone through an initiatory period, and up to now they had not many results to show: no electric light companies, he believed, had. When the Company was incorporated they had negotiations in hand for the sale of concessions, but unfortunately they were not able to carry any of them through. They were not, however, bogus applications, but came from responsible people, most of them being solicitors in London, and if they had been carried out the money would have been returned to the Company in full for the sale of the concessions. The first duty of the directors was to take works where they could show their light and the manufacture of their lamp. Premises were accordingly taken on a small but sufficient scale for their purposes in Newington-causeway, where the lamps had been visible from that time until recently. In the absence of definite orders they devoted their attention to the improvement of their plant and apparatus, and he was glad to be able to say that they had perfected their arc lamp to such an extent, that they were fully justified in saying that it was equal, if not superior, to any other. The Gramme dynamo machines required no eulogy, he supposed they were as good if not better than any other, and their own lamp was all that they required. In the meantime they endeavoured to obtain contracts and tendered in many quarters. Every contract that was offered was considered, but, unfortunately, they were not able to take any at the prices offered. They had, however, succeeded in getting some work which formed the nucleus of what they believed would turn out to be satisfactory employment. They had entered into a contract for the lighting of the Café Monico in Regent-street.

A SHAREHOLDER: Not with your lamp.

The CHAIRMAN begged pardon. He would enter into that shortly. They had taken a small building sufficient for their purpose in the neighbourhood, where their engines would be erected. Very nearly adjoining this building were other buildings, public places of resort and amusement, and in the immediate neighbourhood there were large and fashionable shops. He believed they could extend their operations to all those places, and he hoped that in time they would be lighting the whole of them from the centre he had named. The contract they had was self-supporting, and if from the same centre they could light buildings of much greater magnitude, they had no doubt they would be able to do it at a satisfactory profit. Replying to the remark of the shareholder who had interrupted him, the arc light they were using was their own, but the incandescent lamp they were using was not their own; they had not got one. They intended to use the Brush incandescent lamp, but they did not intend to confine themselves to the lamp if otherwise they could do better for those who used their property. They expected, and, in fact, were sure of having this installation at work before this meeting was held, but little difficulties had arisen which delayed the completion for a few days. It would be but two or three days before the installation was at work satisfactorily, and they would then be able to see for themselves and inspect the quality of the arc and the nature of the lamp, and he hoped they would find it satisfactory. After that they would very likely have to call the shareholders together again, because their funds were pretty well exhausted, and to extend operations they would require more money. The directors intended to consult the shareholders as to the best course to pursue in the matter. In conclusion, the chairman moved the adoption of the report and accounts.

Mr. B. MOORE seconded the motion.

Mr. J. L. HALE said that the directors, in their report, stated that they had perfected the Company's arc lamp, and they considered it in efficiency and economy of working superior to any in the market; but it was stated in the prospectus that the lamp, at the time of issuing that document, was perfect. Another statement in the prospectus was as to the relative cost of the Gramme and Brush dynamos. He had gone into the matter with scientific gentlemen, and found that the Gramme machine was no cheaper than the Brush. He contended that they were not lighting up the Café Monico, and the most astounding fact connected with the Monico business was that the café was not to use their lamp at all. Their electrician told him that they would not have it, that they were going to adopt the Edison lamp, and not the Company's. As to the capital of the Company, the directors had nothing to show them for the £29,000 subscribed; it was all gone, and they were in debt.

Colonel JONES and Dr. WEAVER made some adverse comments on the accounts.

The CHAIRMAN, in reply, said that no electric lighting company was in a much better position than this Company. He did not think it was stated in the prospectus that the lamp was perfected. The contract with the Café Monico was a profitable contract—they were to get £700 a year for the installation, which covered the whole cost of working. With regard to starting with insufficient capital, they did not require much money to go to work, as they did not anticipate a large manufacturing business. If they had to manufacture at all it would be the Chertemps arc lamps. Out of the £29,000 £18,000 was paid to the owners of the land. Of course they believed that every one who subscribed to the Company would pay, but there were £3,420 unpaid. It could not be said that all the money was lost, because it was represented by steam engines, dynamos, &c., and if the shareholders paid up their arrears they could complete the work they had

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in hand, and do what they originally intended to do. The directors were willing to forego the arrears of remuneration due to them.

After some further desultory conversation an amendment was carried that the report and accounts be not adopted, and the meeting was adjourned for three months.

GREAT WESTERN ELECTRIC LIGHT AND POWER COMPANY (LIMITED AND REDUCED).

Report of the directors to be presented to the first ordinary general meeting to be held at the Cannon-street Hotel, on the 3rd Sept., at 2 p.m. :— This Company was formed in April, 1882, to acquire from the Anglo-American Brush Electric Light Corporation a concession for the use of their Brush patents in the western counties of England and the southern counties of Wales. A license to use the Lane-Fox incandescent lamp was also granted over the same area. Shortly after the formation of the Company a similar concession for the county of Cardigan was purchased for £1,000 in cash. In June, 1882, this Company sold its concession and license for Devon and Cornwall to the Devon and Cornwall Electric Light and Power Company, for a sum of £7,500 in cash, and £7,500 in fully paid shares. Owing to various causes the Devon and Cornwall Company is now in liquidation, and under the terms of the agreement, the concession and license for Devon and Cornwall revert to this Company, which is now taking steps to work this portion of its district. The past year has been one of considerable difficulty ; begun with a wild enthusiasm for the new light, and now followed by an equally unreasonable depression. When the depression took place in the autumn of last year, some of your fellow shareholders sought to escape from the liability they had voluntarily taken upon themselves, alleging a misstatement in the prospectus in respect to the Lane-Fox patents. Several actions were brought against the Company, and these have resulted in the surrender of 941 shares, at a cost to the Company of £274 5s. 3d. All claims on this head are now disposed of, and the time is long passed when any further claims can be maintained. Your present Board, in thanking you for your support at the poll in May last, when the numbers were For the present Board 2,120 votes, for the late Board 1,035 votes, have to report that since their election they have used every effort to place the Company on a sound commercial basis, and to develop a profitable business. With this view, the general expenses have been reduced to the utmost, and the lighting stations at Bristol and Cardiff have been developed to a considerable extent, the gross receipts being now as under :—Bristol : Rentals (annual contracts) £350, rentals (lights supplied by the hour) £145—total £495. Cardiff : Rentals (annual contracts) £491, rentals (lights supplied by the hour) £50—total £541, grand total £1,036. Your directors have entered into an arrangement with the Electrical Power Storage Company for the supply of the Faure Sellon-Volckmar accumulators, thus completing their stock of electric appliances, and enabling them to undertake lighting of every kind and also to supply motive power. The late Board had gone to some expense with a view to obtaining provisional orders for Bristol, Cardiff, and other towns under the Electric Lighting Act, but on taking office your directors, in fulfilment of their promise to the shareholders, decided to drop them for the present. The Corporation of Bristol are obtaining an order themselves, and your Company is now in a position, if required, to supply them with all the needful plant to carry it out. In Cardiff your Company is at present free from rivalry, and owing to the cheap rate at which electricity can be supplied on the Brush system is likely to continue so. There are signs of an improved demand for electric lighting this autumn, and your directors believe that by next summer the trading operations of the Company will show a fair margin of profit. With a view to any such profit being available for dividend purposes, your directors recommend that the whole of the extraordinary expenses incurred during the past year for organising the Company, and in connection with the alleged error in the prospectus, should be written off. Your directors have taken all necessary steps to make your shares fully paid up ; but, pending the withdrawal of certain claims made by the liquidators of the Devon and Cornwall Company, the matter is in abeyance. An action has been commenced by one of the Devon and Cornwall Company's shareholders, in which your Company are made co-defendants with the directors, promoters, and solicitor of that company. Your directors will take all necessary steps to protect your interests. The liquidation of the Devon and Cornwall Company has not made sufficient progress to enable the probable return to be estimated, and no value has therefore been placed upon the shares you hold in the company. With a view to the thorough working of your district, agents are being appointed in various counties and towns, who, by their local knowledge and influence, will doubtless secure a large proportion of the electric lighting offering. The result of the fourteen months' working has been a gross profit of £1,706 1s. 8d., which is turned into an actual loss of £3,891 12s. 9d., chiefly owing to the heavy expenditure in fees, travelling expenses, and general charges incurred by the late directors. Taking into account the cash received from the Devon and Cornwall Company, the fourteen months' working show a profit of £112 14s. 6d., after writing off the whole of the preliminary expenses, the extraordinary law charges, the cost of 500 Devon and Cornwall shares, and 10 per cent. depreciation on the plant in use at your lighting stations. This balance it is proposed to carry forward to next year. With a sufficient capital in hand, active and loyal officers, and the best system of electric lighting and storage of electricity, your directors look forward hopefully to the result of their efforts during the next twelve months. The shareholders will be asked to appoint auditors for the ensuing year, and Messrs. Turquand, Youngs, and Co., being eligible, offer themselves for re-election.

NUMBERS OF "THE ELECTRICIAN" OUT OF PRINT.—The following numbers of *The Electrician* are out of print, and cannot be supplied at the office, viz. :—Vol. 1, Nos. 3, 9, 19 ; Vol. 7, Nos. 8, 10, 12 to 18, 20, 21, 24 to 26 ; Vol. 8, 1, 3, 6 to 12, 15 to 26 ; Vol. 9, Nos. 2, 4, 24, 25 ; Vol. 10, No. 13.

COMPANIES' SHARE LIST.

TELEGRAPHS.

COMPANIES.	CLOSING PRICES AUG. 29.		BUSINESS DONE WEEK ENDING AUG. 29. Highest.	Lowest.
Anglo American	47¾,	48¼	48	47¼
Do. Preferred	79¾,	80¼	80	79½
Do. Deferred	17¼,	17½	17½	17
Brazil Submarine	11 13-16,	11 15-16	12	11 15-16
Cuba	11,	11½	—	—
Do. Preference	17½,	18½	—	—
Direct Spanish	5,	5½	—	—
Do. Preference	15¾,	16½	16¼	—
Direct United States Cable	12¾,	13¼	12¾	12 9-16
Eastern Telegraph	10 11-16,	10 13-16	10 13-16	10¾
Do. 6 per Cent. Preference	12⅝,	12⅞	12 15-16	—
Do. 5 per Cent. Debentures, 1899	103,	107	—	—
Eastern Extension	11¼,	11¾	11 7-16	11 3-16
German Union	9¾,	10¼	—	—
Globe Telegraph and Trust Company.	7⅜,	7⅝	7 7-16	7 5-16
Do. Preference	12¾,	13	12¾	12 11-16
Great Northern	12¾,	13	13	12 15-16
Indo-European	31,	32	31	—
Mediterranean Extension	1½,	2	1⅞	—
Do. Preference	2,	4	—	—
Reuter's	8½,	9	8¾	8⅝
Submarine	220,	230	231	230
West India and Panama	13-16,	15-16	1	13-16
Do. 1st Preference	6⅜,	6⅝	6⅝	6½
Western Brazilian	5 15-16,	6 1-16	6	5⅞
West. Union 7 per Cent. 1st Mortgage	122,	124	123	—
Do. 6 per Cent. Sterling Bonds	103,	106	—	—

TELEPHONES.

COMPANIES.	CLOSING PRICES AUG. 29.		Highest.	Lowest.
Consol. Telephone and Maintenance	5-16,	7-16	7-16	—
Oriental	5-16,	7-16	—	—
United Telephone	8,	8½	8⅜	8¼

ELECTRIC LIGHT.

COMPANIES.	CLOSING PRICES AUG. 29.		Highest.	Lowest.
Anglo American Brush Lgt. (£7 paid).	2¾,	3	3 1-16	2⅞
Do. (fully paid)	6,	6½	6 3-16	—
Hammond Light	1,	1¼	1⅛	1 1-16
Eastern Electric (£1 paid)	½,	1	—	—
Swan	1¾,	2	1 15-16	1⅞
Maxim-Weston	1-16	3-16	—	—

MISCELLANEOUS.

COMPANIES.	CLOSING PRICES AUG. 29.		Highest.	Lowest.
Telegraph Construction	33½,	33¾	33⅞	—
India Rubber, Gutta Percha, and Telegraph Works	28,	29	29½	28½

TRAFFIC RECEIPTS FOR JULY, 1883.

COMPANIES.	July, 1883	July, 1882.	Incrse.	Decrs.
Anglo-American Telegraph Company	—	—	—	—
Brazilian Submarine Company	—	—	—	—
Cuba Submarine Company	2,700	2,921	—	221
Direct Spanish Telegraph Company	—	—	—	—
Direct United States Cable Company	—	—	—	—
Eastern Telegraph Company	—	—	—	—
Eastern Extension Telegraph Company	36,177	30,070	6,107	—
Great Northern Telegraph Company	22,[illegible]00	—	—	—
Submarine Telegraph Company	—	—	—	—
West Coast of America Telegraph Company	—	—	—	—
Western and Brazilian Telegraph Company	—	—	—	—

A DAILY TELEGRAPHIC PAPER.—The Pittsburgh Assembly publishes a daily four-page paper filled with items of news in reference to the strike. It is published for free distribution, and, so far as we know, is the first daily telegraphic paper ever issued. Its accounts of the strike are received from many points, and are detailed and comprehensive. The *Dot and Dash*, as the new paper is called, answers successfully its purpose as an auxiliary of the strikers, and when their movement has either succeeded or failed will have no occupation in its present form. —*The Operator.*

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NOTES.

Consolidation of Telephone Companies.—The telephone companies of New England, U.S.A., have resolved to consolidate.

Information Wanted.—A correspondent wants to know if there is any likelihood of electricity supplanting coke as a means of smelting iron.

Honours for an Electrician.—The Earl of Crawford and Balcarres has been elected an honorary member of the Berlin Academy of Sciences.

Reduction of Tariff.—The Eastern Telegraph Company notifies that the rate to Monte Video and other places in Uruguay is now reduced to 11s. 1d. per word.

Hospitals and the Telephone.—St. Vincent's Hospital, the Meath Hospital, and county Dublin Infirmary, have been connected up to the Dublin Telephone Exchange.

An Aged Chemist.—On Friday, the 31st August, M. Chevreul, the famous French chemist, entered upon his ninety-eighth year, having been born on Aug. 31, 1786.

The French in China.—*The Times*' Hong Kong correspondent, telegraphing under date September 1, says:—"The French are laying the Haiphong and Saigon telegraph."

Talking by Electricity.—This is to be the subject of a popular Saturday lecture by Sir Frederick Bramwell, which will be delivered at Southport during the approaching meeting of the British Association.

A Chance for the Electric Light.—The Willenhall (Staffs.) Local Board have given notice to terminate their present contract with the gas company, the ratepayers being dissatisfied at the price charged.

Books Received.—" Professional Papers of the Corps of Royal Engineers," Vol. VIII. "Practical Electrical Units, Popularly Explained," by James Swinburne. Published by E. and F. N. Spon, Charing Cross.

The Telephone on Railways.—It is announced that the Compagnie des Chemins de Fer de L'ouest will after the 1st September discard its present telegraph instruments for signalling purposes on its lines and substitute telephones.

The City Telephone Exchange.—The last number of the *Graphic* contains some capital illustrations of the exterior and interior of the Coleman-street Exchange of the United Telephone Company, showing amongst other things the system of working employed.

Workington (Cumberland).—The Derwent Iron and Steel Works Company have connected their various outlying premises by telephone on the exchange system. Messrs. Tasker, Sons, and Co., of Sheffield, have carried out the work, using the Johnson-Bell apparatus.

Submarine Telegraph Company.—This company notify that a dividend of 15 per cent. per annum for the half year ending 30th June last will be paid on presentation of the coupons either at the Union Bank, 2, Princes-street, E.C., or to Mr. P. Gil, 6, Boulevard des Capucines, Paris.

Windsor Castle.—Considerable alterations and improvements are being carried out at Windsor Castle during the Queen's absence in Scotland. Amongst other things, chambers are being constructed in the North Terrace, which are intended for the reception of electric lighting machinery.

Electric Lighting Contract Company.—Notice has been given that an extraordinary meeting of the members of the Electric Lighting Contract and Maintenance Company will be held at No. 1, Queen Victoria-street, E.C., on the 1st October, at 12 noon, to inspect the accounts of the liquidators.

Military News.—Captain R. H. Jelf, Royal Engineers, who was Adjutant of the Royal Engineers at Aldershot for some years, has assumed command of the C, or Telegraph Troop, of the Engineers at Aldershot, in succession to Lieut.-Col. Sir A. Mackworth, who has left the station for a district appointment.

The Brighton Electric Railway.—This railway, which was described in our last issue, was somewhat damaged by the heavy sea which prevailed on Sunday and Monday last. The shingle on which it is laid was partially removed by the force of the water, and the railway itself had a narrow escape of being washed away.

Another Electric Tramway in Ireland.—A daily paper says:—"The first sod of the proposed electric tramway from Newry to Bessbrook was cut on Tuesday morning. This will be the second electric tramway in Ireland." It is being constructed, we believe, for the Bessbrook Spinning Company, and will be seven miles long.

Fire at the Edison New York Station.—A fire broke out a few days ago in the top story of one of the buildings in Pearl-street, New York, comprising the Edison lighting station. It was soon put out, however, and the damage done was trifling. It is supposed to have been caused by the spontaneous combustion of oily rags.

The Telephone in Belgium.—A telegram from Brussels, dated August 30, says:—"The experiments made for establishing telephonic communication between Brussels and Antwerp by means of the existing telegraph wires, according to the system of M. van Rysselberghe, of the Brussels Observatory, have been perfectly successful."

The Cuba Submarine Telegraph Company.—The number of messages passing over the lines of this company during the month of August was 2,470, estimated to produce £2,275, against 2,579 messages, producing £2,595 in the corresponding month of last year. The traffic receipts for the month of May, estimated at £3,300, realised £3,376.

Electric Lighting in Mills.—A mill situate on the banks of the Doria, near Turin, is lighted by means of 64 Swan lamps. The current is supplied by a Gramme dynamo, driven by the water wheels of the mill. The speed of the dynamo does not exceed 800 revolutions per minute. The installation is reported to give great satisfaction. The Swan lamps have replaced colza oil.

A Mill Struck by Lightning.—On the evening of Friday (August 31) a heavy thunderstorm passed over Oldham. The mill of the Commercial Spinning Company was struck by lightning, and several pounds worth of windows were smashed. The loose material was set on fire, but the hands extinguished the flames with the appliances on the premises. The storm is reported to have been the severest experienced for some time.

The Edison System in the Colonies.—We are informed that the Queensland Government have arranged with the Edison Indian and Colonial Company to place the Edison light permanently in the parliamentary buildings and Government printing offices at Brisbane, and also that "the Government of New South Wales have arranged with this company to place the Edison light permanently in the parliament houses, printing offices, and other buildings."

The Telephone in India.—An Indian paper says: "A proposal has been laid before the Punjab Government for the construction of a telephone line between Dharmsala and Palampur, at a cost of 1,000rs. per annum, half being gua-

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ranteed by the Planters' Association and half by Government. The Government, however, is unable to make this grant from provincial revenues, but has inquired whether the district committee is prepared to guarantee the amount."

Tenders for Lighting Wanted.—The Barking (Essex) Local Board require tenders for lighting their district by gas or electricity for one, two, or three years. Particulars can be obtained at the office of the board, East-street, Barking. Tenders are to be in by the 12th inst.—The Sutton (Surrey) Local Board also want tenders for lighting their district for one, two, or three years from the 1st October. Particulars can be had at the offices, 1, Grove-road, Sutton. Tenders must be in by the 19th inst.

The New Standard Wire Gauge.—The ironmasters of the Wolverhampton district appear to be greatly opposed to the new wire gauge. They state that this standard prejudices them in some of their transactions by from ten to thirty shillings per ton. They recommend the ignoring of the guage in their business, and that instead of by the new standard, sheet iron should be sold according to its weight per superficial foot. The ironmasters, replying to the Board of Trade, had sketched a different standard to that now authorised.

Torpedo Firing at Sheerness.—During last week a series of experiments in submarine mining were carried out by the Royal Engineers stationed at Sheerness. The discharge of a torpedo containing 500lb. of gun cotton caused considerable alarm among the inhabitants of the town, many houses being shaken to their foundations. The shock was severely felt at the dockyard, and the officials were at first at a loss to imagine what was the cause. The experiments at the fort with the electric light were also renewed with great success.

Conductors.—Mr. E. J. Cowling Welch, C.E., has published a small card, which will fit into any pocket book, on one side of which is printed a table giving the relative weights of copper conductors for conveying currents from 1 up to 5,000 amperes, in lbs. per mile. On the back of the card are a few remarks bearing upon the figures given on the front, in which Mr. Welch points out that for economy of working, as opposed to mere safety, larger conductors than those given in the table are required for currents up to 2,741 amperes.

Companies Dissolved.—Notice has been given by the Registrar of Joint Stock Companies that the following, amongst others, have been struck off the register and dissolved, viz.:—Anglo-Danish and Russian Telegraph Company, Anglo-Indian Telegraph Company, Danish-Norwegian-English Telegraph Company, Direct English, Indian, and Australian Submarine Telegraph Company, Electro-Protector Boiler Company, Franco-American Telegraph Company, Provincial and Foreign Telegraphic News Company, Telegraph Works Company, West Indian and American Telegraph Company.

Earthquakes.—On Sunday an earthquake shock was reported to have been felt in Italy at Albano, Ariccia, Genzano, Roua di Pape, Monte Porzio, and elsewhere on the Alban Hills, besides Frascati.—A strong shock of earthquake occurred at 10:20 on Tuesday night at Fontana, Barano, and Foria, followed by another at 10:40. No serious damage was done.—Three distinct earthquake shocks were also felt in Dusseldorf (Germany) early on Wednesday morning. No damage was done here, however.—New York papers report an earthquake at Pachuca, in Mexico, by which twenty persons lost their lives.

Selenium Regulator for Jablochkoff Candles.—The *Electrical World* has received a communication from Lieutenant Bradley A. Fiske, U.S.N., in which he says: "Referring to the electric candle regulator of M. Tomassi, described in your issue of August 11, 1883, I would respectfully suggest that the experiments of Willoughby Smith, Siemens, and others (including myself), show that the conducting power of selenium, on exposure to light, decreases very rapidly, so that it would be impracticable to use it for the purpose indicated." We referred to this regulator in a note in *The Electrician* for July 14.

The Telephone in South America.—"The starting of a regular Telephone Exchange in Rosario, with the Bell instrument," says the *Buenos Ayres Herald* of July 24, "has awakened that province to telephone advantages. The Government at Santa Fé has arranged with Senor Don Pedro Lapez for telephonic communication between its offices, and he has purchased from the United Telephone Company of the River Plate the supplies necessary to establish an exchange in that city. The Rosario Company's business increases rapidly. It has been obliged to order additional instruments and other material."

The American Telegraph System.—A correspondent of the *Daily Telegraph* wired as follows from Washington on Wednesday:—"The Committee of the United States Senate appointed to inquire into the American telegraph system and the advisability of its acquirement by the State on the English plan met to-day. The principal witness examined was Mr. Jay Gould, the eminent financier and president of the Western Union Telegraph Company, who emphatically denounced the scheme for placing the telegraphs under the control of the Government. He affirmed that Government telegraphs must always be inefficient, unstable, and subject to political influence."

The Electric Carbon, Storage, &c., Company (Leith).—With reference to the liquidation of this company we are informed that Mr. J. E. Jackson has been appointed provisional liquidator. A meeting of shareholders has been held, and a committee of advice formed, consisting of Mr. E. Maher (as petitioning creditor) and Messrs. Tait and Knoblanch on behalf of the shareholders, and it is intended to add two gentlemen who will represent the interests of the other creditors. A meeting of creditors will be held in London as early as possible, when every information will be given. It is hoped that all claims will be settled without making a further call on the shareholders.

Ancient and Modern Illumination.—The city of Mexico is described by a recent traveller as a city of contrasts. These contrasts are marked at every turn. In the upper stories of houses are families enjoying every luxury of food, clothing and surroundings, while on the ground floor huddles the family of the portero in their bare rooms, content with scant wages, slight clothing, and the coarse food of their Indian ancestors. The main thoroughfares are lit by the electric light, the neighbouring streets by gas, and further away the rest of the city is lit by the dim oil lights hanging on ropes over the middle of the streets, like those in primitive European towns.—*Electrical World.*

The Edison System in New York.—The last bulletin of the New York Edison Company says:—"The First District, New York City, plant still runs with entire success, being now in its twelfth month of continuous operation, without a stop, even for a minute. Nearly all the customers the station can safely supply are now connected, and we are making no new connections, save in exceptional cases where lights are burned either for many consecutive hours during

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the day or all night. The meter works perfectly, and our customers continue to be satisfied both with the price of the light and the light itself. We are at present lighting 431 houses, wired for about 10,300 lamps."

Domestic Electric Lighting.—Mr. W. H. Holmes, of Wellburn, Jesmond, Newcastle-on-Tyne, has just had his house fitted up throughout with electric lights. The gas has been cut off and entire dependence placed upon the new light. The current is supplied by a Siemens dynamo, driven by a Crossley gas engine of half horse-power. The current from the dynamo is stored in Faure-Sellon-Volckmar accumulators. Swan incandescent lamps are used to the number of forty. The lights, &c., have been put up by Messrs. Holmes and Co., electric engineers, of Westgate-road, Newcastle, of which firm Mr. W. H. Holmes is a member. The brackets and fittings have also been made by this firm.

Conductivity of Silver Haloid Salts.—Herr W. Kohlrausch has found that at temperatures above their melting point, silver chloride, bromide, and iodide conduct electricity much better than sulphuric acid. The order of conductivity is chloride, bromide, iodide. The resistance of the chloride and bromide is increased when they solidify, and rises quickly by cooling, until at 20 deg. it has more than a million times its former value. Silver iodide, on the other hand, does not on solidifying change its resistance in the least at first, but the resistance increases rapidly at the temperature (145 deg.) at which it passes from the amorphous to the crystalline state—*vide Ann. Phys. Chem.*, Vol. 17, p. 642.

The Lighting of Mr. Jay Gould's Yacht.—The Edison Company of New York have lighted Mr. Gould's yacht. The plant consists of one L dynamo, with a capacity of 150 A lamps. The dynamo is driven by a 6½ by 8 Armington and Sims engine, located in the engine room, on the starboard side of the vessel. The main conductors for the light run fore and aft, in four distinct circuits. There are 116 lamps installed in the interior of the vessel. There are also three 32 candle-power lamps enclosed in a Fresnal globe, which serves for the masthead lantern. This, together with the red and green sailing lamps on the port and starboard sides, each of which is lighted by two 32-candle lamps, are entirely new features in steamship lighting. The yacht is named the "Atalanta."

The British Museum.—The lighting of the British Museum by means of arc and incandescent lamps, which has been discontinued during the summer months, was renewed on Saturday last. The lamps are the same as were formerly used, but have been re-adjusted with a view to obtaining as much light as possible. They are distributed as follows:—Four arc lights, suspended from the dome, illumine the reading room; one lights the corridor, two are in use in the hall, and four—instead of two as formerly—light the courtyard of the building. Swan lights are distributed through the lavatories, &c. Last year the minimum light given in the reading room was of about 12,000 candle-power; this year it is 14,000, and it is capable of extension to 16,000—4,000 for each of the large arc lights. The works have been carried out by Messrs. Siemens Bros., under the superintendence of Mr. J. Barrett.

A History of the Telegraph.—The opening of the Vienna Exhibition lends additional interest to Mr. Fahie's "History of Electric Telegraphy to the Year 1837," which is now appearing in our pages. It will be seen from the list of exhibits sent by the Society of Telegraph Engineers and of Electricians to Vienna that amongst them are portions of the original telegraph line laid by Ronalds in 1816, the story of which is so graphically told by Mr. Fahie in this week's issue. We have illustrated the Ronalds telegraph before from drawings made specially for us, but we think that many of our readers will appreciate our Supplement of this week for its archæological interest. The illustrations have been printed from the original copper plates engraved from Ronalds' own sketches in 1823. We are indebted for the opportunity to publish these illustrations to Mr. Sydney Williams, the present proprietor of these plates, and Mr. A. J. Frost, librarian to the Society of Telegraph Engineers and of Electricians.

Telegraphic Reform in India.—The telegraph-postal reform proposed to be introduced shortly in India is described as follows by an up-country paper:—"The present number of telegraph offices in India is, we believe, 1,600, and of post offices 6,000; and when it is explained that the whole of the latter are to be rendered available for the transmission of telegrams, it will be seen at a glance what an enormous increase to the existing accommodation is contemplated. The Postal Department will undertake to receive telegrams at every post office in India for despatch to the nearest telegraph office, prepayment being accepted in postage stamps. Again, wherever the authorities may consider it advisable, the Post Office will place its postmasters at the disposal of the Telegraph Department for the establishment of a regular telegraph office, the mechanical dispositions of which would, of course, remain subject to the telegraph. Under this arrangement many minor telegraph offices, which are now maintained at a disproportionately heavy cost, will be amalgamated with the existing post offices, at an obvious and very considerable saving in establishment charges."

Electric Lighting in Dundee.—A very successful installation of 16 Siemens arc lamps was made last week in Dundee for the Horticultural Society of that town, in connection with their annual exhibition. Visitors found that in the evening the colours of the flowers, down to the finest shades, could be seen under electric light as perfectly as by daylight; and the attendance was far in excess of any previous year. The plants were also found at the close of the exhibition to be fresher than during similar exhibitions where gaslight was in use. The vice-president (Councillor Macdonald), in his address at the close of the exhibition, said: "The illuminations by the Northern Electric Light Company were decidedly the best ever witnessed in Dundee. He had been doubtful about taking the electric light, but now he had to thank Mr. Loring and his company for the brilliant and perfect illumination of the show." The installation was made by the Northern Electric Light and Power Company of Dundee—the pioneer electric lighting company in Scotland—under the superintendence of their manager and electrician, Mr. Oliver Loring. The current was generated by two Siemens alternate current machines, driven by a 12 h.-p. semi-portable engine by Marshall and Co.

A Low Resistance Callaud Cell.—In the *Beiblätter*, Vol. VII., No. 4, Herr Terquem describes a Callaud cell having a very low resistance. A glass vessel, 0·16m. wide and 0·23m. high, containing 5 litres, is provided at the bottom with a tube closed by a cock, into which a glass tube, bent upwards, is placed. At the top of the cell is a brass cross resting on the edge, in which is placed a spiral coil of thick sheet zinc weighing 3kg. A funnel passes through this spiral. On the bottom of the cell lies a copper plate, to the centre of which is attached a copper wire passing up through an inverted lamp chimney of glass. The cell is filled with a 50 per cent. solution of pure crystallised sulphate of zinc; in the lamp chimney are placed crystals of sulphate of

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copper, after a small quantity of the above solution of sulphate of zinc mixed with a saturated solution of sulphate of copper has been poured in. Small strips of zinc hanging down from the brass cross into the liquid prevent the deposition of copper on the zinc spiral. The resistance of the cell with a 60 per cent. solution of zinc is 1·58 ohm. A certain quantity of liquid is drawn off daily into two flasks filled with granulated zinc, which precipitates the copper, and the liquid can then be poured back into the cell through the upper funnel.

Glasgow and Electric Lighting.—At the last meeting of the Glasgow Town Council the minutes of the Health Committee were read, in which it was recommended that a committee be appointed by the Gas Commissioners to consider the practicability of utilising the surplus cinders recovered from the city refuse in raising steam for electric lighting purposes.—The Lord Provost, in moving the approval of the minute, remarked that at the present time there was a very large quantity of cinders that the Cleansing Committee desired to get rid of, and which would raise steam for electric lighting purposes. It was known that the Gas Committee had in contemplation the trial of electric lighting; and if they could arrange with the Cleansing Committee to have the work commenced in one of the localities where cleansing operations were carried on, it could be done at the lowest possible expense. It was with the view of seeing whether some arrangement of that kind could be effected that the committee referred to in the minute was proposed.—Bailie Dron said that if they went in for electric lighting they would be able to utilise large quantities of these cinders in various parts of the city.—The Lord Provost said that the quantity of cinders was so large that the Gas Committee could not possibly take them all.—The minutes were approved of.

Batteries and Dynamos Compared.—The *Centralblatt für Electrotechnik* makes the following comparisons between batteries and dynamos:—A Bunsen element gives an E.M.F. of 1·9 volt, and has a resistance (the ordinary type of ·20 metre) of ·24 ohm. The greatest work is done when the external equals the internal resistance. The difference of potential is then ·95 volt, and the current about 4 amperes. The useful work contained in an element, the return being 50 per cent., is therefore about 4 watts. Now, a dynamo which absorbs 1 horse-power gives about 460 watts; consequently, to replace this machine we must use 115 Bunsen elements. The cost of buying a dynamo of 1 horse-power is about the same as that of a battery of the same power. In point of fact, a Bunsen element of ·20 metre in height costs about 5 francs, or 575 francs for the battery; a dynamo of 1 horse-power costs 500 to 625 francs. For more powerful dynamos the price is relatively much less; thus a 14-light Schuckert machine (for arc lamps), and giving off 5,000 watts useful energy, only costs 3,250 francs. A battery to do the same work would consist of 1,400 elements, costing 7,000 francs, or more than double, and would occupy a surface of about 40 square metres, whilst the dynamo would only take up 2 square metres. The battery would require 280 kilos. of sulphuric acid and 1,050 kilos of nitric acid.

Electric Lighting in New Zealand.—A correspondent sends us the following extract from a report made by the Government printer to the New Zealand House of Assembly, relating to the adoption of the Edison system in the Government printing office. The extract reads as follows:—"The duties of compositors require as large an amount of light as can be obtained. During Session time, when the work rooms are crowded, the use of so many gas lights had the effect of increasing the temperature of the rooms at night by 15 to 20 degrees, in other respects it was objectionable, as so much gas burning seriously vitiated the atmosphere, and consumed the oxygen so needful for the preservation of health. These facts having been represented to the Government their sanction was obtained to the introduction of the electric light. The new illuminator was used for the first time on the 25th May, on which occasion the office was visited by the Hon. the Premier, all the members of the Ministry, and a large number of the leading citizens of Wellington. The light used is Edison's, installed by Edison's (Indian and Colonial) Electric Co. While undoubtedly a cleaner, purer, and cooler light is obtained, it is interesting to know at what cost it is produced as compared to gas. I find that when using the light for five honrs of an evening the cost is 2s. 7½d., and to obtain the same illuminating power from gas would cost 4s. 4½d."

The Electrical Transmission of Power.—*L'Electricité* gives the following account of M. Marcel Deprez's experiments at Grenoble, which we referred to in a recent note:—The generator was placed in the cement works of Messrs. Damaye and Co., at Vizill-Gare, where a hydraulic turbine of 80 horse-power is in use. A double silicium bronze wire of ·002 metre diameter was fitted upon ordinary telegraph poles along the road leading to Champ-Vizille, a third wire of brass serving for telephonic communication. The distance between the market house at Grenoble and the Damaye works is 14 kilometres (eight miles 1,230 yards). In the market hall a small workshop has been set up, in which are an endless band saw, a circular saw, a printing press, a Dumont centrifugal pump, &c., all of which are arranged round the receiver. This latter is the same that was used at Munich, but has been repaired. This time M. Marcel Deprez has endeavoured, if not to suppress, at least to greatly diminish the effects of the distance to be traversed by increasing the electromotive force, hoping to lessen the dangers of so doing by the insulation of the apparatus. He obtains this result by increasing the length of the wire on the machine, and diminishing its diameter. On the first evening, when the public were admitted by card, they were somewhat disappointed to see only the centrifugal pump at work. This raised 1,200 litres of water, and formed a cascade which had a pretty effect. The speed of the generator at Vizille was about 600 revolutions, and it absorbed nearly 14 horse-power. On the Sunday the committee appointed to make an official report verified the result at Grenoble to be 7 horse-power measured on a Prony brake; and at this time the speed of the generator at Vizille was 1,257 revolutions, and it absorbed 45 to 50 horse-power, which corresponds to a return of 15 per cent. However, we shall soon have the report of the technical committee, which was composed of Messieurs Boulanger, captain in the 4th division of engineers, president; Cornier, engineer; Jordan, engineer; Merceron, engineer; Rivoire, civil engineer; Hüs, mining engineer; Viallet, engineer; Labatut; and Périnier, telegraph engineer.

Panama.—An interesting report on Panama has been issued by the Foreign Office in their last volume of trade reports. The acting consul at Colon writes:—"The climate of Panama during the dry season (December to April) enjoys a steady and equal temperature of 27 to 29 centigrade. During the wet season (April to November) the heat is very oppresive, owing to the great dampness of the atmosphere and the want of breezes. Light southerly winds prevail during the wet months, and strong northerly trade winds during the dry. A singular coincidence to be remarked at Panama is that

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the winds during the dry season fall and rise with the tide. This phenomenon also takes place with the wet season, when, at low tide, there is scarcely a breath of air. The showers generally fall as this moment, preceded by heavy storms of thunder and lightning. The air is charged with electricity, and heavy rain clouds hang over the isthmus, which melt in heavy showers as soon as the electricity is discharged in the form of fork and sheet lightning. Within my recollection I have seen buildings struck by lightning; the towers of the cathedral were struck last year, and several large masses of stone were detached by the stroke. Notwithstanding the frequency of these accidents from lightning, there is not a single lightning conductor in the whole town. The railway wharf received a discharge in October last, which tore up and splintered several planks. Three people were killed on the Savanna. . . . The isthmus for 50 years was not visited by any phenomenon such as earthquakes, &c.; very slight oscillations were felt, but nearly imperceptible to a great many. Lately we have had a succession. The first that took place after this long silence was on the 7th of September last year, at 3:20 a.m. The city was roused by a severe oscillation from north to south, accompanied by a rumbling noise. The façade of the cathedral was destroyed, the columns and balconies of the Parliament House were thrown down, and several public and private edifices were rent. Since then we have had a series, varying in intensity, from three to five per month, and the extraordinary coincidence exists that they are regular and more severe at the new moon."

The Griscom Motor.—The Electro-Dynamic Company have fitted up a model installation at Archway House, Bush-lane, Cannon-street, E.C., with the object of showing the Griscom motor at work. The necessary current is supplied by Kabath accumulators, which are charged every night from the Metropolitan Brush Company's lighting station, which is close by. We described the Kabath accumulator in *The Electrician*, Vol. IX., p. 61. The cells are charged by the dynamo which supplies current to the Brush lamps in Cannon-street, by means of wires leading from the lighting station into Archway House. The cells are placed in series with the lamps, and take about 1½ hour to charge. They are of the half horse-power type, and weigh about sixteen pounds each. The current from these cells is used to feed some three or four incandescent lamps and several motors. These latter are shown driving sewing machines, a fan, dentists' drill, &c. The fan is intended for use in houses in warm weather. We were told that it would circulate 800 cubic feet of air per minute. The adaptation of the motor for dentist's purposes is very neatly carried out. The motor is suspended from a pivoted metal arm, projecting from the wall, by a brass tape, which is fitted with a compensating spring, so that the motor can be raised or lowered at will. Motion is transmitted to the drill by means of a flexible steel shaft. The arrangement of the pivoted arm, and the raising and lowering apparatus enable the drill or other instrument to be shifted about with ease, whilst for dentists' purposes the speed of the drill and the steadiness with which the work can be performed are great advantages. It is obvious that drilling work of other classes that has to be carried out in a confined space could also be readily accomplished by means of the Griscom motor and flexible shafting. The various parts of the motor are all made by machinery, and are interchangeable. Steel and gunmetal are chiefly used, and in consequence a motor will wear for a long time. Each motor develops about ¼ man power at 4,000 revolutions, and requires a current of about 2 amperes, and an electromotive force of 12 volts. In the older form, the armature had large pole pieces of iron which considerably overlapped the wire at either end. It has been found that these shoulders have a bad effect, and they have been considerably reduced in the present machines. A small ridge has also been cut along the top of each pole piece, which serves to catch the wind, and, acting like a fan, cools the magnets. The installation at Archway House is intended to show how readily the necessary current can be laid on from the nearest lighting station (they are few and far between now), secondary batteries charged, and the current utilised as required. It remains to be mentioned that Mr. C. R. Heap is the agent of the Electro Dynamic Company in this country, their factory being at Philadelphia.

The Electrical Tramcar in Paris.—*La Nature* publishes an article from the pen of M. E. Rouby, engineer, in which he gives some electrical and mechanical details concerning the system adopted for propelling the electrical tramcar recently experimented with in Paris. It was one of the largest kind constructed by the Compagnie Générale des Omnibus de Paris, could carry 52 passengers, and was not specially made with a view to electrical traction. The mechanical details connected with the fitting of the dynamo and gearing under the car were designed and carried out by M. Raffard. Under the floor was fixed a Siemens D^2 dynamo, the current being supplied by 80 accumulators placed under the seats. The dynamo was connected by means of a belt and pulley, with differential movement, to an intermediate spindle. Two pinions engaging the two ends of this spindle, two endless chains and gearing completed the transmitting mechanism. On the day of the trial the car made a journey of about 32 kilometres, at a mean speed of 11 to 12 kilometres per hour. The total weight of the tramcar, including 80 accumulators of 30 kilogrammes each, was about nine tons. The average current was 35 amperes, with an electromotive force of 165 volts. The electrical work supplied to the machine by the accumulators was therefore $\frac{35 \times 165}{750} =$ 7·7 h.-p. for 2½ hours, the duration of the journey, and the accumulators were far from exhausted. (We may note here that the French h.-p. is not so large as the English, the former being 542½ foot pounds per second and the latter 550.) According to the Paris correspondent of the *Standard*, another trial of an electric tramcar was to be made in Paris on Thursday afternoon. He says:—"The new car will leave the Electric Company's workshop in the Place de la Nation, and will take the following route:—From the Faubourg St. Antoine to the Place de la Bastille, thence along the Boulevard Henri Quatre, and across the Pont Sully to the Boulevard St. Germain. At the Boulevard St. Michel end of the Boulevard St. Germain a short stoppage will be made. The second part of the journey will bring the car to Montrouge, returning to the Eastern Railway by the Boulevard de Sebastopol and the Boulevard de Strasbourg. The Boulevard Magenta will then be reached, and the journey continued past the Northern Railway to the beginning of the Boulevard Ornano. Turning to the left, the whole length of the external boulevards to the Arc de Triomphe, and thence to Passy, will be traversed. The La Muette line of rails will then be followed, *viâ* the Trocadéro, to the Boulevard Haussman, the experiment being completed at the Circular Tramway Office at the end of the Rue Taitbout, whence the car will retrace its journey to the workshops. It will have travelled forty-five kilometres through the crowded streets of Paris—an excellent test of its alleged superiority over the horse cars."

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THEORY OF MAGNETO AND DYNAMO MACHINES.

XXIV.

Consideration of the Effects of Self Induction.

The number of lines of force passing through a contour we formerly called the potential of that contour, and denoted it by $-$ N (see Art. V.). If the contour were a circuit carrying a current γ, it possesses energy equal to $-\gamma$ N, or more strictly to $\int_0^\gamma - N\,d\gamma$.

Until last article, however, we ignored the fact that the current itself created lines of force, and that a circuit conveying a current will have some energy, although it be in space perfectly free from other magnetism.

Return for a moment to the consideration of the simple rails and slider discussed in Arts. IV. and VII.

The motion was there supposed to take place in the earth's magnetic field, and the slider tended to move so as to include more of the earth's lines of force in the circuit. But, although the earth's magnetism may help the motion, it is not essential to it. Directly a current is sent round the circuit some lines of force pass through it, and the circuit tends to enlarge, so as to afford these the greatest possible area.

A flexible circuit, even in a non-magnetic field, therefore tends to expand to its greatest area, *i.e.*, to become circular, directly a current is sent round it; and any movable portion of a circuit tends to move with the same tendency, though the force causing the motion will be but small for common strength of current. The revolving disc, Fig. 3, Art. IV., would rotate, for instance, without either a magnet or the earth's field, provided only the current were sufficiently strong. The contrivance, Fig. 4, however, requires extraneous magnetism, and could not revolve in the strength of its own current alone, because on inspection it will be seen that no motion of the radial arm would increase the area of the circuit, which is a constant.

Instead of motors, if we consider magneto machines or generators, the same considerations apply. The lines of force, which must be cut by a conductor, in order to develop in it induction currents, may just as well be its own lines of force as some due to extraneous magnetism. Only observe that a bodily rotation or motion of a circuit as a whole is now not much use; the circuit must be twisted out of shape somehow in order to develop self-induced currents. Thus consider a simple ring current, like that of a tangent galvanometer, or an earth inductor, able to revolve about a vertical axis, and suppose its plane set magnetically east and west. Certain lines of force are passing through it, not only those due to the earth's horizontal intensity or A H, where A is the area of the ring, but also those produced and maintained by the current itself, a number which depends on the strength of the current, and on the size of the ring. Rotate the ring 90deg. until its plane is magnetically north and south: all the earth lines have been cut by the ring, and are now passing *by* the circuit not *through* it, consequently an E.M.F. has been set up, and a momentary induced current produced in the coil; but lines due to the original current have turned with the coil, and still all pass through it as before, hence no induction effect has been caused by them. To get rid of these lines, or to cut them out of the circuit, it is no use moving the coil about: there are two methods able to get rid of them; one is to shut up the ring, the other is to stop the current. The shutting up of the ring is accomplished by pulling it out into a very elongated oval, and then twisting it up like a rope. The twisting up removes the last trace of an area from it, which the bare closing up would leave. This operation, then, or the breaking of the circuit, removes from it every line of force, whether due to the earth or to itself. The operation, therefore, is attended with induction effects, known as self-induced currents, which may be strong if the operation be rapid.

As soon, therefore, as we consider the deformation or the breaking of circuits, we must, to be accurate, take self induction into account as well as external induction. The number of lines of force sent by a current or magnet through a neighbouring circuit is sometimes called the potential of the current or magnet on the circuit, or more often it is called the mutual induction between the two. It is proportional to the strength of the current or magnet, and equal to this multiplied by a constant, which is called the *coefficient* of induction. Similarly the number of lines of force excited by a current within its own circuit is called the potential of the circuit on itself, or its self-induction. It is proportional to the strength of the current γ, and may be written L γ, when L is a constant depending on the size and shape of the circuit, and called its *coefficient* of self induction.

The total number of lines of force passing through a ring whose normal is inclined at an angle θ to the meridian is, therefore,

$$N = A\,H \cos\theta + L\,\gamma.$$

By turning it slowly round, the first term only varies, becoming zero twice in a revolution; by closing it up on itself both terms vanish; and by breaking the circuit without turning it round the second term only vanishes. Unless the shape or size of the circuit is altered L remains constant.

There are thus several modes of generating induction currents in a coil:—By varying A, by varying H, by varying θ, by varying L, or by varying γ. Changes in A and L would commonly occur together, and would be produced by bending or stretching a flexible circuit. Variations in θ are caused by rotating it. Variations in H can be caused by moving magnets into or away from the neighbourhood, or by actually poking them through the circuit. Momentary variations in γ are caused by all these operations as well as by the use of batteries and switches. No matter how changes in N are brought about, the rate at which it does change is numerically equal to the E.M.F. of induction, and the equation $e = -\frac{dN}{dt}$ is perfectly general.

The total energy of a current in the circuit held normal to the lines of force is (see first sentence of this article) not simply A H γ, as was stated in Art. XIII., where for simplicity self induction was neglected, but is

$$A\,H\,\gamma + \tfrac{1}{2}\,L\,\gamma^2$$

It is to be noticed that the first term is the more purely mechanical energy of the circuit, the second term is the energy of the current itself in the circuit. Now, in many cases, for instance in the simple motors discussed in former articles and supplied with a constant current, the second term remains constant—the first term only varies; and when it is only *variations* of energy that we need consider, it is customary to neglect this purely electrical part of the energy, except at the instant of making and breaking contact when it accounts for the extra currents; in other words, it is often sufficient to take notice of the extraneous lines of force which thread the circuit, and to neglect those belonging to its own current which revolve with it and do not change; and this we have hitherto done.

We now, however, pass on to the more complete case, where the energy and potential are as given above, and the E.M.F. is

$$e = -\frac{d}{dt}\left\{A\,H\cos\theta + L\,\gamma\right\}$$

If a circuit merely revolve slowly in a period T, so that $\theta = \frac{2\pi t}{T}$,

$$e = \frac{2\pi}{T} A\,H \sin\theta.$$

If it remains stationary while the current only is changed,

$$e = L\frac{d\gamma}{dt}.$$

If every possible change occur at the same time, then

$$e = \frac{2\pi}{T} A\,H\sin\theta - L\frac{d\gamma}{dt} - \cos\theta\frac{d\,A\,H}{dt} - \gamma\frac{d\,L}{dt}.$$

It is easy enough to write down the value of e therefore,

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and from that it is not difficult to calculate the strength of the current at every instant.

Case of a Revolving Coil.

To simplify matters, let us suppose that the strength of the field and the size and shape of the circuit remain constant, that is, let H L A not change; let there be no applied battery, but let it be a simple closed ring revolving at a good speed. The difference between fast and slow rotation is this, that for slow rotations the magnetic effect of the induced currents is negligible because they are so weak, and accordingly the term L γ may be left unnoticed. Thus for slow rotations we have simply

$$e = \frac{2\pi}{T} \text{H A} \sin\theta,$$

and by Ohm's law

$$\gamma = \frac{2\pi}{\text{R T}} \text{H A} \sin\theta = \gamma_0 \sin\theta, \text{ say.}$$

The mean or average strength of current (not paying attention to sign) is $\frac{4\,\text{H A}}{\text{R T}}$ or $\frac{2\gamma_0}{\pi}$.

But when the coil spins quickly—so quickly that the induced currents produce a decided magnetic effect—we must take the general value of N, and write

$$e = \frac{2\pi}{T} \text{H A} \sin\theta - \text{L}\frac{d\gamma}{dt}$$

which must equal R γ by Ohm's law.

This equation solved for γ gives us

$$\gamma = \frac{2\pi \text{H A}}{\sqrt{(\text{R}^2\text{T}^2 + 4\pi^2\text{L}^2)}} \sin(\theta - \phi) \; + \; \text{C}\epsilon^{-\frac{\text{R}}{\text{L}}t}$$

(instead of simply $\frac{2\pi\text{H A}}{\text{R T}} \sin\theta$),

where ϕ is an angle such that

$$\tan\phi = \frac{2\pi\text{L}}{\text{R T}},$$

and where C is some constant.

The second term in the above expression may at present be neglected, for it only represents temporary disturbances, which die out in a second or so after the speed becomes steady.

The mean value of the current is now $\frac{4\,\text{H A}\sin\phi}{\text{R T}}$, and this is less than if there were no self induction in the proportion of $\cos\phi$ to 1. The larger L is the larger ϕ is, and the smaller becomes the average value of the current.

Now this ϕ represents the "lag" or the part of the lead due to the rotation, and the above value for it shows that it depends on the speed and on the ratio of the resistance of the circuit to its self induction coefficient; being

$$\tan\phi = \frac{\text{L}}{\text{R}} \times \text{angular velocity.}$$

These equations are rather important, and it is as well to put them into their briefest form.

To do this, call the maximum E.M.F. producible if the ring were cut through, or if self induction were otherwise abolished—call this e_0,

so that $$e_0 = \frac{2\pi\text{H A}}{\text{T}} = \text{H A}\omega,$$

where ω is written for the angular velocity.

And, further, use the symbol $\gamma_0 = \frac{e_0}{\text{R}}$ for the (somewhat unimaginable) current corresponding; viz., the maximum current which would be produced in the ring at the given speed if L disappeared but everything else remained the same.

Then the above equation becomes

$$e = e_0 \sin\theta - \text{L}\frac{d\gamma}{dt},$$

while from it we calculate:

The current in any position

$$\gamma = \gamma_0 \cos\phi \sin(\theta - \phi).$$

The lead $$\tan\phi = \frac{\text{L}\omega}{\text{R}}$$

and the E.M.F. in any position

$$e = e_0 \cos\phi \sin(\theta - \phi).$$

We thus see that the effect of self induction is twofold; first a swinging of the neutral line on which the brush should be set through an angle of ϕ in advance of the lines of force, and secondly, a weakening of the current in every position in the ratio of $\cos\phi$ to 1.

The maximum E.M.F., instead of being e_0, is $e_0 \cos\phi$, and the zero E.M.F., instead of being in the line $\theta = 0$ (*i.e.*, along the lines of force), is in the line $\theta = \phi$.

It is often said that to avoid sparking at the brushes they must be set so that each coil, at the instant it is shortcircuited by them, shall not cut any lines of force. We now see that a better statement is that the coil may not possess any E.M.F., whether self or otherwise produced, and that this (at least for a single-coil machine) makes one place the brushes an angle ϕ in advance of the position we should consider right if we neglected self induction; the angle ϕ being one whose tangent is equal to the speed multiplied by the ratio $\frac{\text{L}}{\text{R}}$.

The ratio $\frac{\text{L}}{\text{R}}$ (or rather its inverse) is called the time constant, and is evidently important. It will be instructive to get an idea of its numerical value for a few cases.

Take a simple solid circular anchor ring or tore, such as was discussed in Arts. XIV. and XV., of total bulk B, mean diameter D, and of a material whose specific electrical resistance is r. It was shown in Art. XIV. that the resistance of the ring would be

$$\text{R} = \frac{\pi^2\text{D}^2 r}{\text{B}}.$$

The value of L can be likewise shown to be

$$\text{L} = 2\pi\text{D}\log(4\,\text{D} - 1{\cdot}75 - \log x),$$

where x is the radius of the cross section of the ring, given by $\text{B} = \pi^2\text{D}x^2$;

Wherefore $$\text{L} = 2\pi\text{D}\left(\log\frac{\pi^2\text{D}^9}{\text{B}} - 1{\cdot}75\right)$$

Hence $$\frac{\text{L}}{\text{R}} = \frac{\text{B}}{\pi\text{D}r}\left\{\log\frac{\text{D}^9}{\text{B}} + (\log\pi^2 - 1{\cdot}75)\right\}$$
$$= \frac{a}{r}\left(\log\frac{\text{D}^8}{a} - {\cdot}597\right)$$

if a is the sectional area of the transverse section of the ring.

The numerical part of this is of insignificant value, and hence, though it varies somewhat for differently shaped transverse sections of the ring, it does not make much matter, and may be altogether neglected with convenience. So we may write, with sufficient practical accuracy for any reasonably shaped ring of mean area A and of sectional area a,

$$\frac{\text{L}}{\text{R}} = \frac{a}{r}\log\frac{\text{A}^4}{a},$$

the logarithm being, of course, a "natural" one.

If the ring, instead of being solid, be composed of a number of strands of insulated wire—making a spiral of, say, n turns—the resistance is rather more than n^2 times, and the self induction also rather more than n^2 times, as great as it was for the solid ring; consequently the ratio $\frac{\text{L}}{\text{R}}$ is not very greatly altered. But if the coil contain an iron core, L is much bigger, while R obviously remains the same; hence now the ratio increases, but it is not easy to calculate. It can be determined experimentally for any coil whatever.

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ON PHOTOMETRY.

BY THOMAS T. P. BRUCE WARREN.

The introduction of the electric light renders it necessary for electrical engineers to be acquainted with the principles and arrangements for testing the illuminating power of different lights.

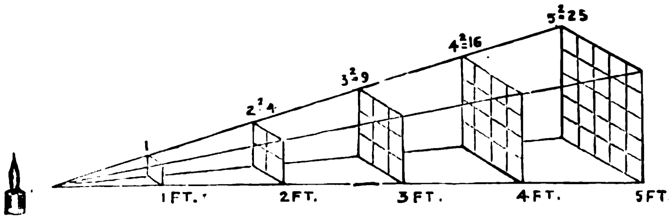

FIG. 1.

The fundamental principle upon which the testing of illumination depends is that the intensity of illumination varies inversely as the square of the distance from the source. This is well illustrated by the familiar diagram shown in Fig. 1. nated, and this is found to depend upon the squares of the distances.

The intensity of illumination is then correctly stated to be the reciprocal of the square of the distance, or is inversely proportional to the square of the distance. Thus at distances of

1ft. area illuminated	1^2ft. =	1 = unity.	
2ft. „ „	2^2ft. =	4 = $\frac{1}{4}$ „	per unit of area.
3ft. „ „	3^2ft. =	9 = $\frac{1}{9}$ „	„ „
4ft. „ „	4^2ft. =	16 = $\frac{1}{16}$ „	„ „

In practice it is necessary to adopt some standard means of illuminating for reference or comparison. The standard adopted by the gas companies in this country, and sanctioned by Act of Parliament, is that light which is given out by the combustion of a sperm candle, weighing six to the pound, and burning at the rate of 120 grains per hour.

Without dealing with the causes which render the candle an unsatisfactory standard for reference, it is assumed that a candle burning more or less than 120 grains per hour is giving out an amount of light exactly corresponding to the rate of combustion.

If candles could be bought which could be depended on,

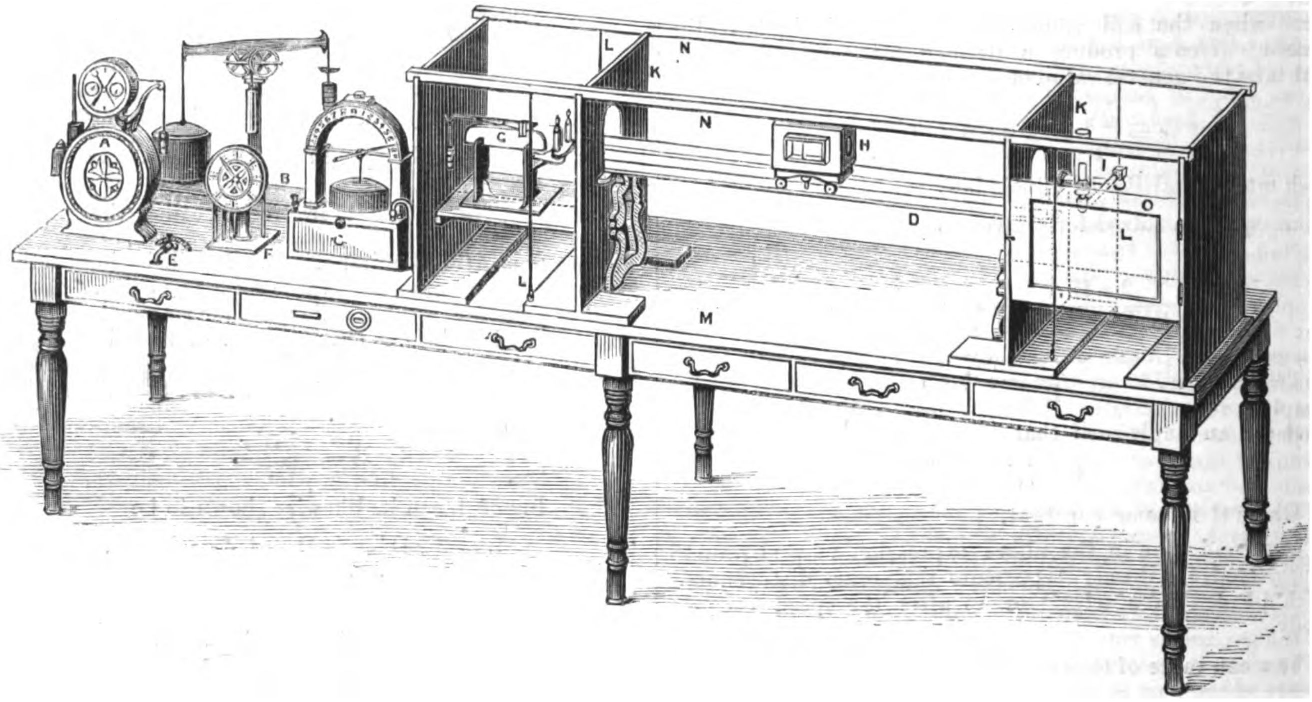

FIG. 2.

Let A be a source of illumination, a candle, for instance, and let the light pass through a small hole or slit and fall on a screen placed, say, at the distance of one foot from the light, each unit of surface of the screen will be uniformly illuminated; as we increase the distances from the light it becomes more scattered, so that per unit of area we have a lower degree of illumination. The above diagram illustrates this diffusion or scattering of the light, which may be thus enunciated:—"The area illuminated varies directly as the square of the distance from the light." If we wish to express the amount or intensity of illumination of a given area, we measure the distance of the illuminated area from the light, and by squaring that distance we have an expression, which by itself has no meaning, but by reference to a fixed unit of distance enables us to say what the illumination is relatively to that at the unit distance. Thus, if we have a screen 1ft. square at the distance of 1ft. from the light, and at the distances, 2, 3, 4, &c., feet we place a screen so as to intercept all the rays of light falling on the screen at the distance of 1ft., we shall find that our screen must be 4, 9, 16, &c., times the area for the corresponding distances of 2, 3, 4, &c., feet, so that as the whole amount of light is diffused over this increased area, the intensity per unit of area is diminished exactly as we increase the area illumi-

nothing could be simpler for photometric purposes; being liable, however, to variation, other means have been proposed to fix the value of the standard candle light, the last, and, perhaps, the best and simplest being that proposed by Mr. Vernon Harcourt, which was described in this journal a short time ago.

For testing the illuminating power of ordinary gas flames the candle light, where generally two candles are burnt side by side, may do very well, but it is obvious that for testing or comparing large lights a multiple of the standard is necessary.

There is considerable difficulty in obtaining reliable multiples of illuminating power, such as can be used for powerful arc lights. In the earlier days of the photometry of the electric light a single candle was used for comparison, and the unequal intensities of the lights to be compared were such that long galleries about 80ft. or 120ft. were used; consequently the earlier records contain the errors due to the candle multiplied by the ratio of the distance of the illuminated disc from the lights respectively.

The most convenient photometer is that which is known as Bunsen's, or a modification of it, the part retained being the greased disc. A piece of white, stout porous paper is saturated with spermaceti, a portion in the centre being left untouched. If we look at this prepared paper by reflected

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light the centre will appear white, and the greased portions will appear dark; but if viewed by transmitted light it will appear dark in the centre, whilst the saturated parts will appear light, due to the power of transmission, through the translucency of the greased parts.

If such a disc is held between two lights, each light will illuminate the side of the disc, the opaque portion in the centre will show an unequal illumination on the two sides if the lights are unequal, but by moving the disc nearer to the weaker light, and consequently further from the stronger one, a point will be found where both sides will appear equally bright.

The greased disc is placed in a sighting box at the back of which are two slightly inclined mirrors, so that the observer can see at once the reflected appearance of the central part of the disc at the same time. The sighting box slides along a graduated bar, and carries an index or pointer, which is immediately under the disc. The graduation of the bar for ordinary purposes is given in candles and fractions of candle-power; for electric light work it is better divided into inches and tenths.

Fig. 2 is a form of photometer which requires a dark room for its use, and is well adapted for measuring ordinary lights. This is known as Dr. Letheby's system, and it is supplied by Mr. William Sugg, the well-known gas engineer, of Westminster. This photometer is made in a form which dispenses with a dark room, by making it higher, with the top part of the frame work projecting so as to carry curtains, which can be drawn together when the apparatus is in use.

A regulator or governor is placed between the supply pipe from the main and the gas meter A, so that the gas enters A under an equal pressure, no matter what changes may be taking place by opening or closing other supplies drawn from the same pipes. The gas meter has a capacity of 144 cubic inches when filled to the mark in the water gauge, which is supplied with glass sides. A thermometer is inserted in a box fixed on the outlet side of the meter. From the meter the gas passes to the balance governor B, thence through the quadrant cock E to the gas burner. The governor B is simply a very delicately-balanced gas holder, which accommodates itself readily to any changes which may arise. By means of the quadrant cock the consumption of gas can be easily and accurately adjusted.

The pressure at the different parts of the apparatus can at any time be tested by King's gauge C, a four way cock F, with circular dial plate engraved "inlet of meter," "outlet of meter," "governor," and "burner," showing the point to which the lever should be turned for connecting the indicated part of the apparatus with the balance-governor.

The candle holder and balance G is placed so that the centre of the flames is evenly between and in a line with the plumb bobs L L. The gas bracket I and burner are similarly supplied with plumb bobs, L L, so that the flame can be adjusted at its proper distance. The sighting box H slides along the bar D, which is supported at its ends by brackets or by resting on the bottoms of the slits pierced through K K, which allow the lights to fall on to the disc in H, which has an opening in each end large enough for the light, and on a level with the two lights. The door O at one end is glazed with blue glass. The rods N N support and fix the ends in their proper positions. The whole is fixed on a bench, M, fitted with drawers. A flap hinged to the front is more convenient for getting to the connections which are attached to the under side of the bench. Instead of Keates's candle balance, it is better to use the lamp and balance designed by the late Mr. Keates, both of which are also supplied by Mr. Sugg.

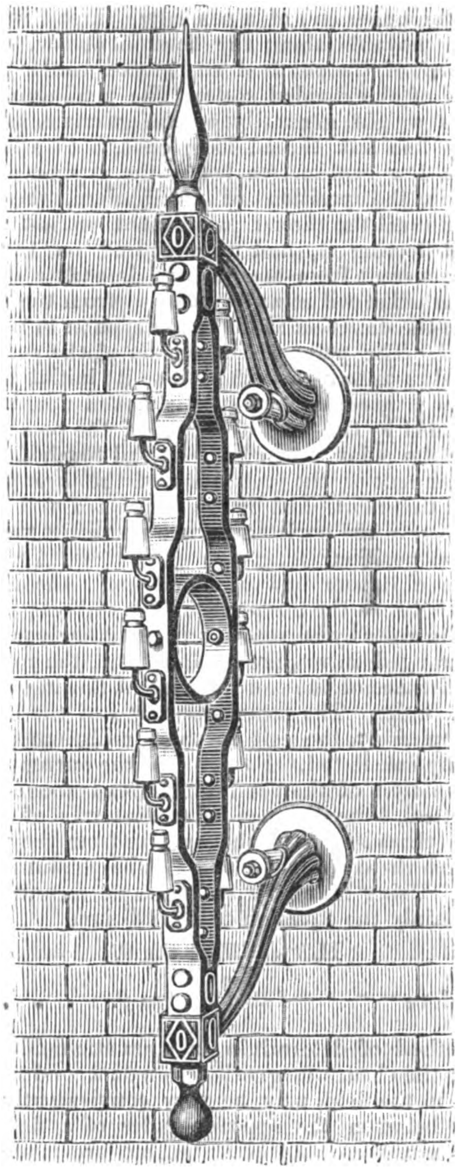
The lamp is simply an accurately constructed moderator lamp burning sperm oil, and giving with a 3in. flame about 16 candle light, when it should consume 200 grains oil in 20 minutes. Preference should be given to "winter made oil," which is freed from the solid matter which is liable to separate out by cold. The lamp should occasionally be taken to pieces and well cleaned. Fresh oil should be used as often as possible; oil which has remained in the lamp for any length of time should be emptied out. A fresh wick should be used for each day's tests.

(TO BE CONTINUED.)

ORNAMENTAL WALL BRACKET FOR TELEGRAPH OR TELEPHONE LINES.

We herewith give an illustration of a wall bracket for telegraph or telephone lines, which has been designed by the well-known firm of telegraph engineers and electricians, Messrs. Johnson and Phillips, of Charlton, Kent.

This bracket, whilst possessing great strength and giving more than the usual space between the wires, has a pleasing appearance, and is constructed to gratify the tastes of those who insist upon fixtures of this nature, when placed on their property, being as ornamental as possible. It is easily and most firmly fixed by passing right through the wall two rods of iron, which are secured in the usual manner by nuts. Although only twelve insulators are shown in the engraving, the bracket can, by a slight modification of the fittings, be readily made to carry double that number without materially decreasing the distance between the wires or detracting at all from its symmetrical appearance.



Johnson and Phillips' Ornamental Wall-bracket for Wires.

This bracket was amongst Messrs. Johnson and Phillips' exhibits at the International Electric Exhibition which took place last year at the Crystal Palace, and it attracted a considerable amount of attention not only from persons interested in telegraphy, but also from the general public.

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DETERMINATION IN ABSOLUTE UNITS OF INTENSITIES OF POWERFUL MAGNETIC FIELDS.*

By A. GRAY, M.A., F.R.S.E., Chief Assistant to the Professor of Natural Philosophy in the University of Glasgow.

(CONCLUDED FROM PAGE 371.)

The following modification of the same method has been used for the determination of I for several recorder magnets, with results agreeing well with those obtained (for other instruments) by the first method described above. A horizontal bar, carrying a divided scale, was fixed parallel to the equilibrium position of the plane of the coil, in a vertical plane passing through the glass syphon a little beyond the point of the aluminium arm supporting it. A single block, to which the upper end of a pendulum-thread was attached, was made movable along the horizontal bar, so that any displacement of the point of suspension could be observed by means of the divided scale. The pendulum was made of a brass weight, generally of one gramme, as bob, hung by a very fine silk thread long enough to allow the bob to hang a few centimetres below the syphon. When the coil was in the position of equilibrium, the pendulum was moved until the thread just rested against the syphon without deflecting it, and the reading on the scale was noted. A current from one or two Daniell cells was then sent through the coil so as to deflect it from the equilibrium position in the direction to cause the syphon to press against the thread. The point of suspension of the pendulum was then moved so as to restore the coil to its initial position, and the distance through which it was moved noted. This distance, divided by the vertical height of the point of suspension above the point at which the thread touched the syphon, gave the tangent of the inclination of the thread to the vertical; and this multiplied by the downward pull in dynes on the weight gave the horizontal force restoring the coil to its equilibrium position.

When equilibrium had been obtained, the difference of potentials between the terminals of the coil was immediately measured in volts by means of a potential-galvanometer previously arranged in readiness; and from the result and the known resistance of the coil the current flowing was deduced in C.-G.-S. units. The mean intensity I of the field over the space occupied by the coil in the equilibrium position was then easily calculated. For let γ be the current in the coil, θ the inclination of the pendulum-thread above the syphon to the vertical, l the distance in centimetres of the point at which the thread touched the syphon from the vertical axis round which the coil turned, and W the pendulum-weight in grammes. Using L and b with the same meaning as before, we have plainly the equation of equilibrium

$$IL b\gamma = Wgl \tan\theta,$$

and therefore
$$I = \frac{Wgl}{L b \gamma} \tan\theta. \qquad (6)$$

The method of determining a magnetic field-intensity by measuring the electro-magnetic action on a conductor carrying a current in the field, may be very convieniently applied to the space between the opposite poles of a field magnet in which the armature-coils of a dynamo are made to revolve. A rectangular frame of stout copper wire or narrow copper strip, containing one or more turns (insulated from one another if there are more than one), is constructed of such a size that two opposite sides are at a distance apart equal to the diameter of the armature, and of length equal to the length of the pole-faces. The rectangle should begin and end near the middle of one of the two other sides; and the two ends of the wire should be brought out side by side, insulated from one another, at right angles to the side, a distance of two or three inches. A pair of knife-edges, which may be made for ease of a piece of hardened copper or brass wire filed so as to have a nearly triangular section, are soldered, one at the centre of the side where the ends of the wire are brought out, the other at the centre of the opposite side; so that the rectangle is symmetrical on the two sides of the knife-edges, and is horizontal when the knife-edges are turned downwards. The sides on which the knife-edges are placed may conveniently be slightly bent so as to have an upward convexity, in order that the line of knife-edges may, when the wire frame is made to rest on them, be a little above the centre of inertia of the system, in order that the frame may rest stably in the horizontal position; or the frame may be loaded so as to have sufficient stability by pieces attached below the knife-edges. The ends of the wire are to be bent first a little up, then downwards so that the point of one is about an inch nearer to the frame than the other, and both points are nearly in the line through the knife-edges.

The field-magnets are set up so that the plane cutting their pole-faces in which the field-intensity is to be measured is horizontal; and two supports, carrying metal V-shaped rests for the knife-edges, are arranged so that the frame when resting on its knife-edges has the two sides lying along the pole-faces in the horizontal plane through the two parts of these faces near which the field is to be determined. Two cups containing mercury are arranged on a support so placed that the ends of the wire of the frame dip into the mercury, without touching the sides or bottoms of the cups. One terminal of a convenient battery is connected to one of the cups; and the other terminal is so arranged that the circuit can be completed by depressing the terminal into the other cup, or broken by raising it, when required.

When an experiment is made the magnets are excited by a current of the required amount, and a measured current is sent round the frame, which is made to turn on its knife-edges by the electro-magnetic action. A weight which can be slided along the frame is hung on one of the sides which carry the knife-edges, and moved to such a distance from the line of knife-edges that the frame is brought back to its initial position. This distance in centimetres and the mass of the weight in grammes are carefully determined, with the strength of the current flowing in the frame; and the mean intensity of the field over the space occupied by the part of the frame in the field calculated from the results. Let I be this mean intensity, L the length of wire of the frame in the field, b the horizontal distance in centimetres of each side from the line of knife-edges, W the mass of the equilibrating weight in grammes, and r its distance from the line of knife-edges, g the acceleration produced by gravity (= 981 centims. per second per second), and γ the strength of the current in C.-G.-S. units; we have by equating moments,

$$I = \frac{Wr}{L b \gamma} g. \qquad (7)$$

If instead of a single weight, W, several weights, W_1, W_2, &c., at distances r_1, r_2, &c., be used to restore equilibrium, we have of course, instead of Wr in this formula, simply the sum $W_1 r_1 + W_2 r_2 +$ &c.

Another modification of this method may be convenient in some cases. The field-magnets may be so placed that the plane cutting the poles in which the intensity is to be determined is vertical, and a rectangle made of the proper dimensions and hung by a torsion-thread or wire, or by means of a bifilar, so that it is in equilibrium in the required position, and turns when deflected round a vertical axis bisecting it. The ends of the wire forming the rectangle are carried down, insulated from one another, from the middle of the lower side, and bent so that their points are in the vertical line bisecting the rectangle, and dip, like the terminals of an Ampère frame, into two mercury-cups placed one above the other on supports arranged below. Two pendulums are arranged so that their points of suspension can be moved along horizontal bars at right angles to the equilibrium position of the frame, one in the vertical plane through each side of the rectangle. These pendulums carry at the ends of light but strong threads equal known weights; and each pulls horizontally on the corresponding side of the rectangle by means of a thread attached at one end to the middle point of the side, at the other to the pendulum-cord. The pendulums and threads are so arranged that the pulls are applied in opposite directions; and thus when the pulls are equal they give a couple tending to turn the frame round a vertical axis. Corresponding to each pendulum are a pair of horizontal scales, arranged like those shown in Fig. 2 (see

* From the *Philosophical Magazine*.

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p. 370, last issue), by means of which, in the manner already described, the tangent of the inclination of the pendulum to the vertical is at once read off.

The method of experimenting is similar to that last described. The magnets are excited, and a measured current sent round the suspended rectangle, from a battery connected with the mercury-cups, in the direction to cause the rectangle to turn round in the direction opposite to the motion which the pendulums are arranged to produce. The points of suspension of the pendulums are then moved so as to restore the frame to the initial position, and the tangents of the inclinations of the cords obtained by means of the scales. If the field be symmetrical about the axis of suspension of the coil, the electro-magnetic action of the frame will be a pure couple, and the equilibrating forces will form also a couple; but in general this will not be exactly the case. Let W be the mass, in grammes, of each pendulum-weight, θ_1, θ_2 the inclinations of the pendulum-cords to the vertical, and let L, b, γ have the same meaning as before; we get by equating moments of forces,

$$I = \frac{Wg}{L\gamma}(\tan\theta_1 + \tan\theta_2). \quad . \quad . \quad . \quad . \quad (8)$$

(γ) The third method is one which has been frequently used in the Physical Laboratory of the University of Glasgow, and consists in exploring the magnetic field by means of the induced current in a wire moved quickly across the lines of force over a definite area in the field. The wire is in circuit with a reflecting "ballistic" galvanometer—that is, a galvanometer the system of needles of which has so great a moment of inertia that the whole induced current due to the motion of the wire has passed through the coil before the needle has been sensibly deflected. The deflection thus obtained is noted, and compared with the deflection obtained when, with the same circuit, a portion of the conductor is made to sweep across the lines of force over a definite area of a uniform field of known intensity, such as that of the earth or its horizontal or vertical component.

In performing the experiments, it is necessary to take precautions to prevent any action except that between the definite area of the field selected and the wire cutting its lines of force. For this purpose the conducting-wire, which is covered with insulating material, is bent so as to form three sides of a rectangle, the middle one of which is of the length of the portion of field to be swept over. This side is placed along one side of the space over which it is about to be moved, so that the connecting wires lie along the ends of the space; and the open rectangle is then moved in the direction of its two sides until the opposite side of the space is reached. The connecting wires thus do not cut the lines of force, and the induced current is wholly due to the closed end of the rectangle.

Instead of a single wire cutting the lines of force, a coil of proper dimensions (for many purposes conveniently of rectangular shape), the mean area of which is exactly known, may be suspended in the field with its plane parallel to the lines of force, and turned quickly round through a measured angle of convenient amount not exceeding 90°; or it may be suspended with its plane at right angles to the lines of force and turned through an angle of 180°. If n be the number of turns, A their mean area, and I the mean intensity of the field over the area swept over in each case, then, in the first case, if θ be the angle turned through, the area swept over is $nA\sin\theta$, and the number of lines cut is $nIA\sin\theta$; in the second, the area is $2nA$, and the number of lines cut is $2nIA$.

In order that with the feeble intensity of the earth's field a sufficiently great deflection for comparison may be obtained, it is necessary that a relatively large area of the field should be swept over by the conductor. One convenient way is to mount on trunnions a coil of moderately fine wire of a considerable number of turns wound round a ring of large radius, like the coil of a standard tangent-galvanometer, and arranged with stops so that it can be turned quickly round a horizontal axis through an exact half-turn, from a position in which its plane is exactly at right angles to the dip. This coil, of course, always remains in the circuit of the ballistic galvanometer. The change in the number of lines of force passing through the coil in the same direction relatively to the coil, produced by the half-turn, is plainly equal to twice as many times the area of the turn of mean area as there are turns in the coil (the effective area swept over) multiplied by the intensity of the field.*

A sufficiently large area of the earth's field, for comparison, may otherwise be obtained very readily by carrying the wire along a rod of wood (say two or three metres long), and suspending this rod in a horizontal position by the continuations of the conductor at its ends from two fixed supports in a horizontal line at a distance apart equal to the length of the rod, and securing the remaining wires in circuit so that they may not cause disturbance by their accidental motion. The rod will thus be free to swing like a pendulum by the two suspending-wires. The pendulum thus made is slowly deflected from the vertical until it rests against stops arranged to limit its motion. It is then quickly thrown to the other side against similar stops there, and caught. The straight conductor thus sweeps over an area of the vertical component of the earth's field equal to the product of the length of the rod into the horizontal distance between the two positions of the conductor at the extremities of its swing. The rod may be placed at any azimuth, as the suspending portions of the conductor in circuit, moving in vertical planes, can cut only the horizontal lines of force; and the induced currents thus produced have opposite directions and neutralise one another.

The calculation of the results is very simple. By the theory of the ballistic galvanometer (the same *mutatis mutandis* as that of the ballistic pendulum), if q be the whole quantity of electricity which passes through the circuit, and if θ be the angle through which the needle has been deflected, or the "throw," we have

$$q = \frac{2}{G}\sqrt{\frac{\mu H}{m}}\sin\frac{\theta}{2};$$

where μ is the moment of inertia of the needle and attachments, m the magnetic moment of the needle, H the earth's horizontal magnetic force, and G the constant of the galvanometer. If θ be small, as it generally has been in these experiments, we have

$$q = \frac{1}{G}\sqrt{\frac{\mu H}{m}}.\,\theta,$$

and the quantities of electricity produced by sweeping over two areas, A and A′, are directly as the deflections.

Let A be the area of the field or portion of field the mean intensity (I) of which is being measured, A′ and I′ the same quantities for the known field, q, q' the quantities of electricity generated in the two cases, θ, θ' the corresponding deflections supposed both small; we have

$$q = \frac{AI}{R} = \frac{1}{G}\sqrt{\frac{\mu H}{m}}\theta,$$

$$q' = \frac{A'I'}{R} = \frac{1}{G}\sqrt{\frac{\mu H}{m}}\theta',$$

where R is the total resistance in circuit; and therefore,

$$I = \frac{A'\theta}{A\theta'}I'. \quad . \quad . \quad . \quad . \quad . \quad . \quad (9)$$

If convenient, θ and θ' may be taken as proportional to the numbers of divisions of the scale traversed by the spot of light in the two cases.

I may remark, in conclusion, that the method described in (a) above gives, when the intensity of the field has been accurately measured by another method, theoretically a method of determining a resistance in absolute electro-magnetic measure. This method is nearly the converse of that given by Weber, in which a magnet is made to oscillate within a coil of wire the circuit of which is closed. What I venture to propose is to hang a coil, the constants of which are known, in a sufficiently intense and uniform magnetic field, and find the decrement of the oscillatory motion produced by the induction; for it would scarcely be possible, I think, to observe with sufficient accuracy the point at which the coil just became "dead beat." How far this method may be practicable can hardly be affirmed without experiment; but I think the necessary calculations and corrections would be, in some degree at least, simpler than those required for the method given by Weber.

* The method of reducing ballistic observations to absolute measure by means of an earth-inductor was used by Professor W. H. Rowland in his "Experiments on the Magnetic Permeability of Iron, Steel, and Nickel," *Phil. Mag.*, Vol. 46, 1873.

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ANSWER TO CORRESPONDENT.

C. E. Mellish.—*Yes, even supposing you could get the drawings, which is very improbable, you would be liable to legal proceedings if you attempted to make the machine. Not having the original source from which the description of the battery was taken, cannot say what metal the tray was made of.*

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*** With this week's number is issued No. IV. of *The Electrician* Supplements, which consists of illustrations of Ronalds Telegraph.

WONDERLAND OF SCIENCE.

There is a period in the rise and development of scientific education when the predominant motive of inquiry is pure and simple wonder. It is most powerful in the early life both of nations and of individuals. Under favourable conditions it exerts such fascination that the youth who begins by wondering on his own account will devote the rest of his days to discovering fresh wonders for other people. The fact is one of everyday experience, though it is usually described in more high sounding terms. Perhaps wonderment is not the best designation that could be found; but it is, at all events, as good as "love of truth," and, as regards young students, certainly more accurate. The young care very little for truth, and young nations nothing at all. What they like is to be astonished, the chief difference ultimately between the wonder workers and the wonderers being that the one has had leisure to inquire, and the other has had none. Once upon a time the former were the world's high priests or magicians, and the latter their submissive and admiring followers. Nowadays the masters of mystery would have it otherwise, their chief burden of complaint being that the world will not listen to their explanations, but prefers to gaze and wonder. They have succeeded just so far as to disillusionise their disciple, but not far enough to make him grateful.

That the world at large, including the most civilised portion of it, has not yet passed beyond the stage of childish wonderment is pretty evident from what we see around us. Love of the marvellous is as strong as ever, and of unexplained marvels strongest of all. An audience is never wanting to witness phenomena the meaning of which is a profound, or concealed, mystery; and even where science succeeds in being truly popular it has to stoop somewhat to the arts of the conjuror. We have seen a good deal of this in our own country of late; so much of it, indeed, that some people who are not scientifically minded begin to complain that they have been deceived. Their capacity for wonder has been worked up to the pitch of parting with money, not in paltry guineas to witness non-scientific impostures, but in good round sums to encourage the genuine article, and, let us add, to make a profit by it. These people were not scientific, but for the moment they fancied they were, and the scientist took great pains, in pursuance of his honest desire of making science popular, to encourage the delusion. The result has been to demonstrate that a little science is a dangerous thing, at any rate in the share market.

Having confessed this much about ourselves, we may take leave to say a word or two about our younger brethren. The people of America, if we may judge by their scientific organs, are peculiarly infantile in their devotion to wonderland. We import most of our wonders from that quarter, but they are as nothing to those that are retained for home consumption. Sermons are as popular as ever with the descendants of the Puritans, but their modern preacher is of the lay order, and he discourses chiefly on science. What he tells them is, as a rule, pure, unadulterated marvel, and they are greatly edified. We gave some samples from the modern American pulpit a few weeks ago, and they illustrate very appropriately the subject we are commenting upon. "I have seen an organ played by electricity," said one of these retailers of modern magic; but this he assured his audience was a trifle. Electricity, that "elusive and subtle element," which is "born of the sun may be converted back to its source," and the result is that "when one talks by telephone he may see his distant colloquist." We have heard something like this on our side of the water, but the effect was spoiled by our being told how the thing might be done. The American lecturer is more primitive in his method, and so are his followers in their capacity. In another place they are told that electricity—electricity is at the head of the occult sciences just now—is a vast current of liquid force which can be condensed in boxes like dessicated meat, and then spread over continents according to taste. After this we are not surprised to learn that man can never overdraw from "this vast, bankruptless depository of nature;" though we think that the American language fails when it says of the telephone merely that it "enables people to make contracts through an orifice." One may say as much as that for the lowly letter-box; but the charm was probably in the word orifice. Then, again, these people whose souls are rejoiced by scientific phrases naturally take pride in being foremost with scientific facts. If anybody in Europe asserts that he has invented or

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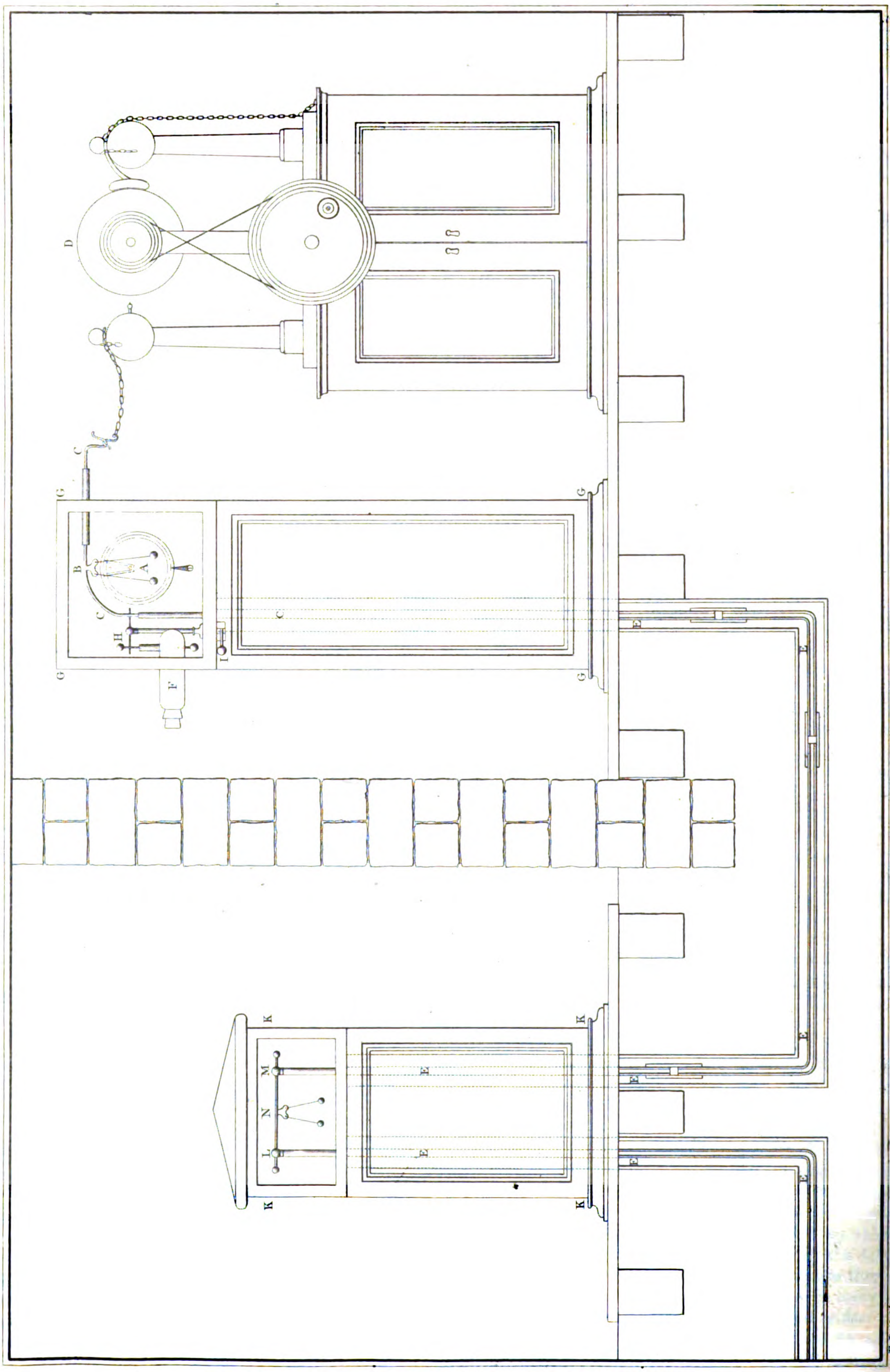

Lowry, sculp.

F. R. del.

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Fig. 4

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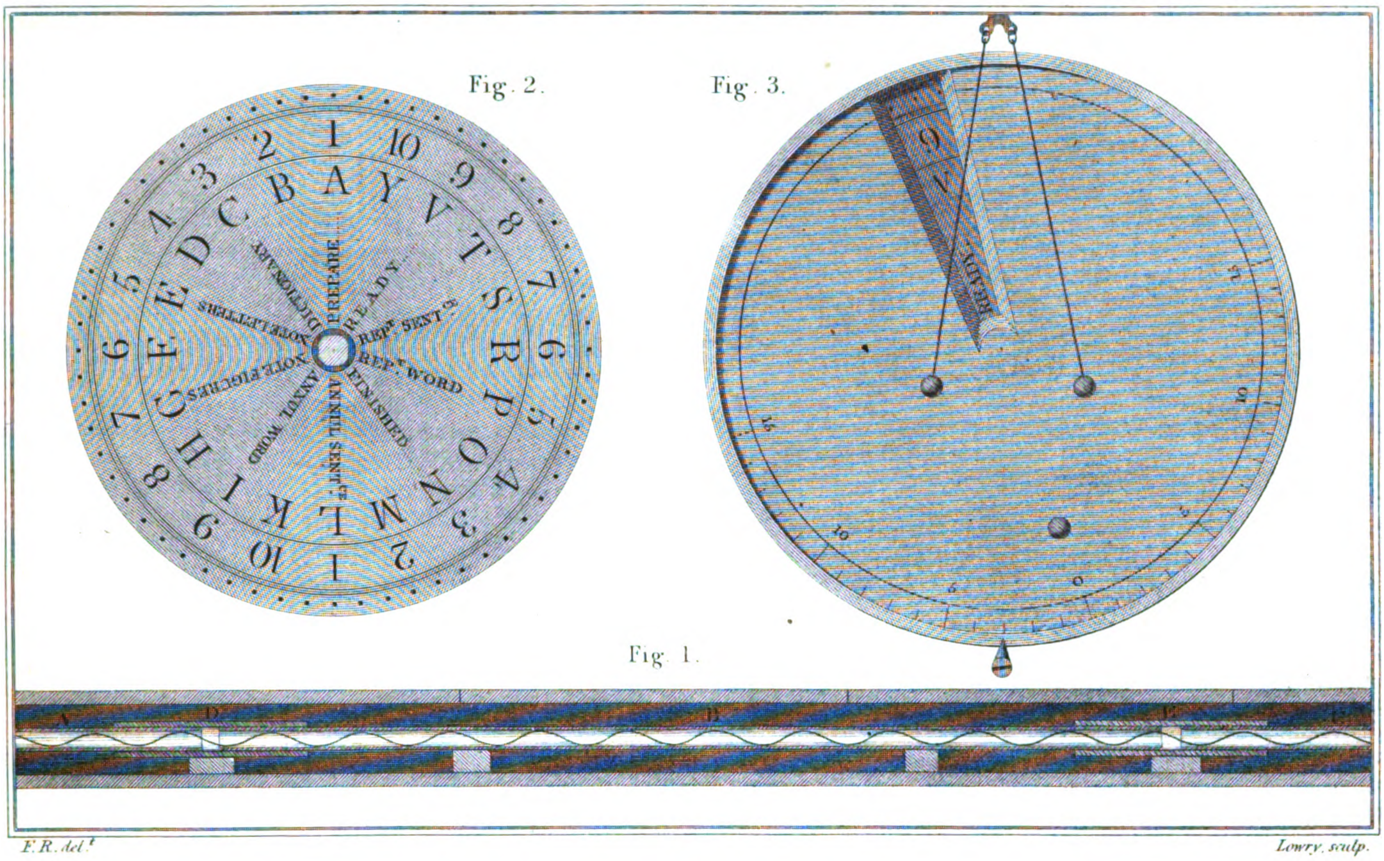

F.R. delᵗ. Lowry, sculp.

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discovered something, America is instant in unearthing a native who did the same thing half a century ago, and we get his biography in full. He constructed an electric machine when he was ten years of age, the biographer being unaware, apparently, that all boys of ten—the age of wonderment—construct electric machines.

Somebody else in the same quarter of the world has discovered, or is about to discover, a means of storing wind power. On closer inquiry, however, we find that this is one of the tricks which the language of wonderland is apt to impose upon us, and is on a par with "seeing" an organ played "by" electricity. It would be cruel to explain what is really meant by stored wind power; but obviously it does not mean economising in the sense of withholding a constant and plentiful supply of that commodity. There is enough wind—scientific wind—in the United States to keep the whole world in a breeze without the help of a store; but it must be owned the demand for it has not yet failed, nor probably will fail so long as the world retains its pristine taste for the wonderful and its preference for unexplained marvels.

DEATH OF MR. C. F. VARLEY.

We regret to have to record the death of Cromwell Fleetwood Varley, which took place at his residence at Bexley Heath on Sunday last. As the funeral was fixed to take place on Thursday, his mortal remains will have been laid in their last resting place before these lines are in our readers' hands. Although his health had been very precarious for some time his death was unexpected. His friends had hoped for considerable benefit from a tour which he made in the autumn of last year with his friend, Mr. W. H. Harrison, through Southern Europe and Switzerland. He appeared better on his return, but it was only the last flicker of the candle of life. He leaves behind him a widow, with two sons and two daughters. The death of Cromwell Varley adds another to the list of losses which electrical science has sustained in the last few months. In December last we lost W. T. Henley, and in January C. V. Walker, whilst in June we had to record the deaths of William Spottiswoode and Sir Edward Sabine.

Cromwell Varley was intimately connected with cable work in its earlier days, and his name occurs frequently in the text books devoted to this branch of telegraphic engineering.

On his mother's side he was related to Oliver Cromwell, through Cromwell's daughter who married General Fleetwood, and his family are among the nearest surviving relatives of the Protector. He was born at Kentish Town on the 6th of April, 1828. His father, the late Cornelius Varley, also a man of science and an artist, was a chief pioneer of the school of water-colour painting in this country, and the actual originator of the Old Water-colour Society; he likewise invented the graphic telescope, ground the first diamond lens, and was noted for his improvements in and researches with the microscope. His brothers, Frederick and S. A. Varley, are well known in the electrical world.

In his younger days Cromwell Varley led an active life; he was of strong frame, and excelled in swimming, which enabled him to save two or three lives, for which the Royal Humane Society gave him a testimonial. In the early days of telegraphy he began to devote his life to the engineering branch of that science, and one of his first original feats was to devise a method of locating distant faults in land wires, which made him known to many scientific men of the day, including W. Fothergill Cook, Robert Stephenson, and General Wyld. One discovery after another was made by him, until he finally became chief engineer and electrician to the Electric and International Telegraph Company, in which position he remained until the telegraphs were taken over by the Government. His inventions and discoveries have been so numerous that but a few can be mentioned here. His patents date from August, 1854, to the present year. Prominent among his early inventions was an apparatus for transmitting electrical signals, the chief points of which were a double current key and a polarised relay, the negative current being employed for the first time not only to discharge the line, but acting on a polarised relay instead of a spring, increased the sensitiveness and trustworthiness of the relay so much that it became practicable for the first time to work from London to Edinburgh direct, a feat previously impossible in the then existing conditions of insulation. Polarised relays and double current keys of modified form are in use to this day. Extending his researches further, the system of using a negative current to eliminate the absorbed charge in submarine cables enabled a higher rate of signalling to be obtained, and communication between London and Continental towns by relaying the current was established for the first time. This system forms the groundwork of all modern methods of signalling through submarine cables.

Cromwell Varley was associated with Robert Stephenson, Sir William Fairbairn, and others in devising the first successful Atlantic cable, the earliest one having failed from faults both in construction and design. He read a paper before the Institute of Civil Engineers, in which he gave the dimensions of the copper core and the gutta percha dielectric, from which he calculated that a speed of fifteen words a minute would be obtainable. He was able to do this in consequence of having constructed an artificial line, consisting of a series of five German silver resistances, to which at regular distances were attached induction plates or condensers made of alternate sheets of varnished paper and tinfoil, whereby he reproduced the phenomena of the inductive absorption and retardation of any projected cable the electrical properties of which it was desired to know beforehand. With this apparatus during the time of the construction of the actual Atlantic cable he was continually experimenting. This apparatus he exhibited at work one evening in public during his lecture at the Royal Institution on submarine telegraphy. He arranged it as a submarine cable from England to South Australia, putting in reflecting galvanometers at imaginary stations at the distances of Gibraltar, Suez, Aden, Bombay, Point de Galle, and so on. The galvanometers were placed in front of the lecture table one above the other, so that when at rest they threw a vertical row of spots upon the screen behind, a feat requiring in itself no mean skill in adjustment; in fact, it was a delicate experiment to attempt to perform at all before an audience. When the current was sent, Gibraltar received it almost instantly, Suez shortly after, but it was a long time in reaching Australia, and then produced but a slight deflection, thus powerfully disabusing the minds of non-technical observers of preconceived ideas as to the speed of electricity. He took occasion to remark that the speed of electricity varies with the inductive condition of every wire used, and that Wheatstone's solitary experiment as to the speed of electricity, so often quoted in school books and text books of the last generation, is altogether untrustworthy. One evening during a walk from Beckenham to Bromley he conceived the idea that under certain conditions an infinitely small charge of electricity might be increased to an infinitely large one, and on his return, by means of two insulated kitchen saucepans and an intermediate carrier, he succeeded in getting a strong spark from an original feeble charge, produced by rubbing a stick of sealing-wax. This led to his construction of a machine which was exhibited in the great exhibition of 1861, the simple rotation of which machine produced powerful electrical effects. Sir William Thomson afterwards used this principle in his "multiplier," which has been found useful in various electrical instruments, and it is the foundation of the now popular Holtz's electrical machine. One of his inventions, of more philosophical than practical use, partly because of out-of-door conditions of insulation, was a kind of singing or humming telegraph. An iron wire about 4ft. long was strained over a kind of fiddle case, and near its centre was surrounded by an insulated coil of wire which did not touch it; the sending instrument

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was a vibrating tuning-fork, which threw as many pulsations of electricity into the line wire per second as corresponded with rate of harmonic vibration of the stretched wire in the receiving instrument, which therefore set up a humming noise when the current passed. Other receiving and sending instruments had other rates of vibration, so that when all were connected with one line wire, each receiving instrument would respond to its own sending instrument and no other, and in his experiments at Fleetwood House, Beckenham, which was built by him, the instruments were humming away like humble bees possessed of deep rich bass voices. He and Sir William Thomson invented the curb key for sending impulses through long cables, and leaving the cable in a neutral state after the first impulse had produced the desired signal on Sir William Thomson's reflecting galvanometer at the other end. This was done by sending five or six positive and negative impulses into the cable, most of which subsequently neutralised each other, and left the cable ready for the reception of a new signal. In his evidence before the House of Commons Committee on Submarine Telegraphs, Sir William Thomson bore testimony to the perfection to which he had brought cable testing by the aid of the use of good resistance coils, the want of which had been felt by Sir William during the part he took on board one of the ships in the first Atlantic telegraphic venture. Mr. Latimer Clark was the first to lay down pneumatic pipes for the conveyance of written messages over short distances in the City; Mr. Varley improved and expanded the system, adding to it some ingenious apparatus by which the carrier would open the door and let itself out at the end of the journey, instead of leaving this to be done by the assistant in charge, whose time and attention were to that extent liberated. He was a fellow of the Royal Society, and a member of the Council of the Society of Telegraph Engineers and of Electricians.

Cromwell Varley never wrote a book, although it is stated that he had one in hand consisting of tables of figures, the result of elaborate calculation, for the use of electricians. His own records of his discoveries will be found chiefly in the Patent Office, in the *Philosophical Transactions of the Royal Society*, the *Journal of the Society of Telegraph Engineers and of Electricians*, and in the *Proceedings* of various other scientific bodies.

THE INTERNATIONAL ELECTRICAL EXHIBITION AT VIENNA.

(FROM OUR SPECIAL CORRESPONDENT.)

I.

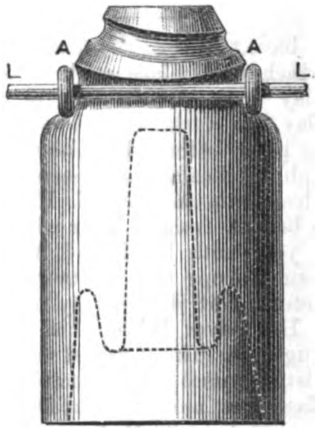
VIENNA, SEPT. 4.—We have hitherto entered into few details as to exhibits, because of the backward state of things at the opening of the exhibition, but great efforts have been made to complete the stands, and in the course of a few days almost everything will be in place. Some of the exhibitors of dynamos and lamps are waiting for more power, which it is hoped will shortly be supplied. Altogether, by the time these lines can be read, the exhibition will be practically complete.

The building in which the exhibition is held has been described, and plans given in our columns.* It is at some little distance from the town, but the tram lines run to within a short distance of the building, the latest extension having been opened a few days ago. The first impression one gets on entering the rotunda is that it is admirably adapted for such an exhibition, and a longer acquaintance with the building renders the impression a certainty. The exhibits are well arranged, and the lighting is effective. There may, perhaps, be but little that is new in the shape of apparatus to describe, but, as we have pointed out over and over again, there is another value in exhibitions of this kind, in showing the rapidly succeeding modifications of apparatus as applied to electric lighting—that most recent of the applications of electricity. We have, then, no hope of recording any great advance, but we shall endeavour to describe and illustrate the various exhibits, so that the modifications which obtain since the Paris Exhibition may be understood.

Our attention was of course directed in the first place to the English exhibits. There is here nothing of a startling nature. Many cases indeed are unpacked, and, as we have said, a day or two must elapse before the exhibits are complete. Around the small pavilion we find the Post Office exhibit. This consists of historical and modern apparatus, and will be referred to in detail in a future letter. Just behind the pavilion is a court in which a number of English exhibits are to be found. In the centre of the court is a room fitted up in Oriental fashion, and lighted by incandescent lamps. Several other rooms fitted up as drawing, dining, bed rooms, &c., open out of this court, as does a refreshment room, through which we pass to a small theatre. All these are admirably lighted, the chandeliers especially being of chaste design, and the whole display for the interior lighting is very good.

The exhibits, commencing on the left, are as follow:—

The TELEGRAPH INSULATOR COMPANY have a display of Lewis's self-binding insulator. This insulator is made of similar material to other insulators, but its peculiarity consists in the "threaded" top. A piece of bent wire fits into one of the threads, ends in two hooks holding the line wire,



Lewis's Self-binding Insulator.

as shown above. In the Fig. A A are the hooks of the holding wire, L L the line wire.

Next to this stand is the exhibit of Messrs. J. STIFF and SONS, which is principally devoted to exhibiting insulators, battery jars, accumulators, and porous cells. These are shown in every variety of form and material. Insulators are shown in two kinds of ware, specially hard vitrified brown stoneware, and a highly glazed and vitrified white stoneware. A considerable number of these are mounted with galvanised iron bolts and nuts, and fixed to a wooden bar to show at a glance how they would appear in use. All the well-known and generally used forms of insulators are shown, and also some very small ones suitable for the finest wires. We notice among the insulators specimens of Slater Lewis's patent self-binding insulator with screw-top, which at once adjusts itself to the wire loop, and immediately holds the wire as firmly as if the usual binding wires had been employed. This patent can be applied to most of the ordinary forms, and only adds about 12s. per gross to their cost. In porous cells one of the specialities of this firm's make is a hard fired cell for bichromate batteries, giving a fairly regular resistance of from two to three ohms. These have been supplied to H.M. Post Office, the Indian Government Telegraph Department, Great Northern Railway, and others, as have been large quantities of porous cells, Leclanché size, with glazed-top edges to prevent disintegration through crystalline deposit. The battery jars and accumulator jars are both brown and white, intensely hard, and well glazed. It will be remembered that an exhibit of similar goods gained a medal at the Paris Exhibition in 1881. Besides the porous

* *Vide Electrician* for August 4 and 11.

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jars, insulators, &c., we find here displayed specimens of plumbago and clay crucibles, tubes, &c., for use in various ways, and brown and white stoneware, as used in chemical and electrical apparatus.

The next exhibit, that of Messrs. Crossley, of Halifax, is very interesting to all engaged in telephonic work. The apparatus shown is admirably constructed, the workmanship and finish being equal, if not superior, to anything of the kind we have previously seen. Here is shown a small exchange, with a new instrument, embodying, or rather called, "the ring off" system. It is not very easy to describe the simple modification introduced into the well known Crossley magneto instrument without diagrams, which, however, we hope to have ready for our next letter.

The India Rubber, Gutta Percha, &c., Company, commonly abbreviated by us into the Silvertown Company, shows an assortment of cables for submarine telegraph work and for torpedo work. Among other specimens we notice samples of the shore ends of the Dieppe, River Plate, Japan, French, and other cables, as well as in some of these cases samples of the deep sea and intermediate types. There are also specimens of lead covered subterranean or tunnel cables, some insulated with gutta percha, others with caoutchouc. On the other side of this court we come to the stand of

The Eastern Telegraph Company, with one of Sir W. Thomson's syphon recorders, worked by a Thomson tray battery. This company, by the way, has a station at Trieste, and is, as is well known, the largest cable company in the world. Quite recently a correspondent asked for a description of this wonderful electrical apparatus, and although it has more than once been described, we may take an opportunity of giving a description for the benefit of the younger members of the profession; but as this involves careful illustration, it must be relegated to the immediate future. Following the stand of the Eastern Telegraph Company is that of

The Telegraph Construction and Maintenance Company, showing specimens of the cables made and laid by them since 1854 to the extent of 65,400 miles. This case of specimens is of immense use to students and others interested in submarine telegraphy, showing as the specimens do, in the most complete and admirable manner, the progress made, and the modifications introduced in the type of cable during these years—that is, in fact, from the infancy of cable manufacture. These cables have been laid in all parts of the world, for the great cable companies, and for our own and for foreign Governments. Further on

The Gutta Percha Company has an elegant case, containing a number of specimens of gutta percha covered wire, gutta percha in its raw and in its manufactured state. Here, too, are samples of Willoughby Smith's composition, and cells made of this composition, various instruments, such as Elliot Brothers' pattern of Sir W. Thomson's galvanometer, various keys and condensers, as made by Elliot Brothers. We also notice specimens of Willoughby Smith's joints, and of the 1850 Dover-Calais, and 1858 Atlantic cables.

The exhibit of the Society of Telegraph Engineers is rather backward. Just outside the court is the exhibit of Mr. Killingworth Hedges, of which more anon. We ought to have mentioned that at the entrance on the opposite side is the exhibit of M. F. I. Zifferer, where are seen in action driving fans, sewing machines, &c., and the well known Griscom motor of the Electric Dynamic Company, of Philadelphia.

Turning from this brief summary of some of the English exhibits, we will conclude our first letter with a translation of the rules under which the committee for testing and examining the apparatus shown has been appointed:—

Programme of the Scientific Commission.

1. A scientific commission will act during the holding of the exhibition for the purpose of taking, in concert with the respective exhibitors, electrical measurements and conducting other scientific researches. This commission will have power to give certificates relating to the results obtained.

2. The scientific commission is composed of a committee established for this purpose by the exhibition commission, and members elected by this committee to act on the scientific commission. This power of nomination is not confined to the members of the exhibition commission. Foreign Governments are invited to send delegates to act as members of the scientific commission. This latter will elect a president, several vice-presidents, and a secretary.

3. The scientific commission will be subdivided into eight sections, to deal with:—(1) Scientific apparatus. (2) Motors and general mechanics. (3) Dynamo-electric machines. Electric lighting and the transmission of power. (4) Electro-chemistry. (5) Telegraphy, telephony, electric bells and clocks. (6) Signals for railways and military uses. (7) Electro-therapeutics. (8) The applications of electricity from an artistic, industrial, and technological point of view.

4. Members of the scientific commission are allowed to belong to one or more sections at will. Each section will choose from amongst its members a president, vice-president, and secretary.

5. The sectional presidents will form a council, which will assemble under the presidency of the president of the scientific commission when required, and will deliberate and decide in place of this latter.

6. If so decided by a section, persons other than members of the scientific commission can be admitted to trials and scientific experiments; and they will accordingly have a voice in the consultations of the section.

7. Exhibitors who may wish to submit their exhibits to trial should make their request in writing to the scientific commission through the medium of the committee of management.

8. The president of the scientific commission will at once forward these requests to the respective section, which, however, has the power to refuse the trial asked for. In case of dispute on this subject, the council will decide.

9. Each of the different sections must keep exact records of the trials and measurements they may make.

10. The certificates to be delivered according to section 1 shall be drawn up on the basis of the propositions made by the different sections, after they have been deliberated on and agreed to by the council.

11. These certificates shall be signed by the president and secretary of the section which has conducted the trial, and by the president of the scientific commission.

12. All resolutions of the scientific commission, council, and sections shall be taken by the majority of votes. In case of equal voting, the president's shall decide.

13. Reports on the labours of the scientific commission shall be published.

For the Committee of the Scientific Commission,
the Committee of Management,

Rodolphe Chevalier de Grimburg. Charles Pfaff.

Vienna, 27th April, 1883.

The Gale.—We are nearing the stormy season of the year, and have just had a taste of what is to come. As usual, our overland lines have suffered considerably. The gale of Sunday and Monday was a fearful one, and appears to have covered a wide area. At home it caused temporary cessation of the telegraph service, notably that to the continent, whilst abroad it seems to have had much the same effect, save and except on those lines which our German and French neighbours have buried where no gales can touch them. The storm seems to have been general over Europe, for we hear of great damage being done in Italy both by wind and lightning, whilst at Vienna it fanned what was an expiring fire into a fearful conflagration, damaging property to the extent of three million florins. At Vienna, also, we hear that the masts supporting arc lights at the entrance to the Rotunda were blown down, damaging the lamps and reflectors. Considering its force, however, the gale does not seem to have caused such damage to our telegraph lines as might have been expected, which says a great deal for the way in which they have been put up.

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CORRESPONDENCE.

ON THE PHENOMENON OF INDUCTION IN THE GRISCOM MOTOR.

TO THE EDITOR OF THE ELECTRICIAN.

(Translation.)

SIR: There is a future for good motors of small power. The date of the distribution of electricity will be followed by an extended use of this agency as a motive power for numerous domestic purposes.

In the construction of small motors the most important matter is economy and simplicity of construction. For this reason electro-motors are usually constructed on the principle of the Siemens armature.

A small motor constructed so as to avoid the use of an armature, always costly to wind, would entirely satisfy the condition imposed on it. I do not know whether such a motor has yet been constructed. To do so seems difficult, but it should not be impossible. The study of small motors is, then, of direct interest.

In the Griscom electro-motor a very interesting phenomenon takes place, which has often been studied by those who cultivate the science of electricity. In this motor it is a question of the advantage of induced currents. No one has yet completely explained why the apparatus is benefited by the induced currents which are developed in it.

Mr. Heap, the representative of Mr. Griscom in England, has put forward a theory of this machine, but it affords no explanation of the curious fact which I have mentioned.

M. du Moncel has also dealt with this question in *La Lumière Electrique*, for the 16th December, 1882, as well as in a communication published by *L'Electricien*, for the 13th February, under the heading "On the Character of Induced Currents Resulting from the Reciprocal Movements of Two Magnetic Bodies Parallel to their Axis." He arrives at this conclusion: That the induced currents resulting from the approach of the inducing poles of the polarised core are in the same direction as the current which has caused the latter to be magnetised, when the poles which are opposed at the moment of this approach are of the same name, which is the reverse of the ordinary cases of electro-magnetic induction. It is this circumstance which should explain the above-mentioned peculiarity of the Griscom motor.

The principle thus enunciated when applied to machines amounts to saying that induced currents have a good effect when the inductor revolves before the wire spirals; but that this is no longer the case when the spirals are revolved before the inductor, as is the case in dynamo machines.

To explain at once why the induction effect is different in the two cases, we need only ascertain how the carrying forward of the magnetism of the armature and the wire by the effect of rotation is brought about in the machines we are considering.

In dynamo-electric machines the inducing poles (*poles inducteurs*) are not sufficiently powerful to maintain the poles of the ring (*poles de l'anneau*) in the theoretical position determined by the influence of the inductors. The line of the poles is carried forward by the rapid rotation of the ring, and the greater the speed of the machine the greater the displacement of the neutral magnetic axis.

It is not alone the core of the magnet (*induit*) that is subjected to this kind of action. The wires of the ring (*anneau*) also experience it. But the continual displacement of the magnetism is more readily effected in the body of the core (*noyau*) than in the wire which covers it. For a given speed of the ring the angle of displacement is greater for the wire than for the core. The soft iron of the movable armature acts on the coils of wire as an inductor (*inducteur*). It follows from this that the displacement of the magnetism of the ring (core and wire) corresponds to a difference between the actions exerted on its two component parts.

Thus, the points of contact of the brushes of the machine do not correspond to the theoretical points of the magnetic displacement in the wire and the ring. The maximum current that we are able to collect *does not therefore represent the sum of the induction effects at our disposal.*

Now, the magnetic influence in the wire determines another neutral line, $f f'$, on which the points of contact of the brushes should be placed in order to collect the maximum current resulting from direct induction.

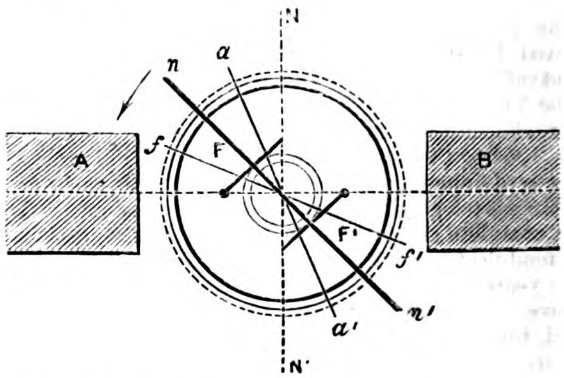
The displacement in the core determines the position of a neutral line, $a a'$, on which the contacts should be placed, to collect the maximum current resulting from the magnetic reaction of the ring.

The current collected at the neutral axis $n n'$ does not, therefore, represent the sum of the maximum induction effects produced in the two parts of the ring.

When, however, the inductor is rotated in front of the ring, the magnetic action takes place equally and at the same time in the two parts of the armature. The positions of maximum direct induction in the wire and of magnetic effect in the core correspond, and it is possible to collect the sum of the effects thus produced.

This circumstance may, perhaps, explain why M. Griscom's motor derives more benefit from the currents developed in it than is the case with other motors.

It shows further, that in transmitting power by means of electricity the magnetism of the machine acting as receiver is greater than that of the generator, owing to the difference between the speeds of the two machines. This fact has been pointed out by M. Frölich, who has demonstrated it in a work, "On the Electrical Transmission of Energy" (see *L'Electricien* for 1st April, 1883, and *La Lumière Electrique* for 24th March).



A B. Inducing poles. N N'. Theoretical neutral line. $n n'$. Magnetic neutral line, caused by the influence of the magnetism of the ring. On this line the brushes F F' make contact with the collector.

Finally, the difference between the influence of the magnetism in the wire and in the material of the core makes it plain that in every way it is advantageous to use thick wire for dynamo-electric machines, whether these machines are designed for the transmission of power or specially intended for small motors.

The theory just put forward will still further be true if we suppose that the wire of the ring has less resistance than the mass of soft iron forming the core. There will always be a certain amount of action tending to the discharge of the two induction effects of the armature. On the other hand, when the electro-magnet passes before the coils, the magnetism available represents the sum of these effects.

From this we conclude that, from the point of view of the influence of the speed on the magnetism, it would be advantageous to give a differential speed to the component parts of the ring, that is to say, to the wire and core. This, however, is scarcely attainable in practice.—Yours, &c.,

ALBERT BANDSEPT.

Brussels, August 27, 1883.

RETENTION OF THE CHARGE OF STORAGE BATTERIES.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: The storage battery which lights this house received

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a dynamo current for the last time on July 2nd, and afterwards lighted the house on the short evenings of July 2nd and 3rd. Nineteen cells had still a considerable residual charge, which unfortunately I did not determine when I left for Norway on July 6th. Returning on August 24th I found, to my surprise, that seventeen of these cells still manifested great activity, and on that evening my dining room was lighted with electricity stored 54 days previously.

The E.M.F. of these cells (originally about 2·1 volts) now varied between 1·3 and 1·8 volt. A determination of the charge still left in two of them gave, in one (determined by the specific gravity of the acid) 376 ampere hours; and in the other (determined by discharge through a Siemens electro-dynamometer) 214 ampere hours.

The cells are of salt-glazed earthenware soaked in paraffin internally, and varnished externally, and they rest on a layer of felt upon a cement floor.

This result shows that, with good insulation, carefully made storage batteries lose their charge with extreme slowness.—Yours, &c., E. Frankland.

The Yews, Reigate Hill, August 30, 1883.

ON THE ECONOMY OF SIEMENS AND HALSKE'S INCANDESCENT LAMP.*

BY SIR WILLIAM SIEMENS.

The question of the economy of incandescent illumination is a double one, and should take into consideration the cost of installation and the cost of working. In a certain sense the two are inter-dependent, for if, for example, a certain number of 16 candle lamps can be worked with a relatively small application of power, a corresponding reduction in the machinery is possible. But a very important item besides is the cost of the conducting system, and in this respect the difference between the various systems is remarkable. In both respects has the incandescent lamp of Messrs. Siemens and Halske made considerable progress of late, as we will shortly describe.

We will first give a table showing the comparative values of the magnitudes concerned in the cases of the new Siemens and Halske lamps, their former lamps, and the Edison A lamp.

—	New Siemens and Halske Lamps.			Earlier Siemens and Halske Lamps.			Edison A Lamp.
	II.	IV.	VI.	II.	IV.	VI.	
Normal candles	12	16	25	12	16	25	16
Volts	100	100	100	102·1	101·4	101·7	100·4
Amperes	·41	·55	·80	·50	·72	1·15	·71
Ohms (warm)	244	182	125	204	141	88	141
Volt amperes	40·05	55	80	51·5	72·6	116·9	71·5
Candles per elec., h.-p. ..	210	206	221	165	157	152	159

The lowest row of this table, giving the number of normal candles furnished per electrical horse-power, shows the advantage of the new Siemens and Halske lamps in the economical application of the power creating illumination. As was stated in the March number of the *Electrotechnische Zeitschrift*, 1883, an improved economy can be effected both by increasing the temperature and by a judicious choice of the substance of the reflecting surface. Care must, however, be taken that changes in this respect do not lessen the durability of the lamps. The improved results of the new Siemens and Halske lamps are entirely due to a new choice of the carbon material, and to its mode of preparation. Though it would be extremely hard to give an exact assurance that the temperature of the carbon filament of the new lamps is no higher than with the old lamps and the Edison A lamp, still a fair indication of the fact may be found in the comparison of the colour and the polish of the filament; for colour is a very delicate index of differences of temperature. The table shows that about 160 normal candles can be obtained per electrical horse-power. The change in this useful effect with a few candles is also apparent. The Edison A lamp, and the Siemens and Halske II., IV., VI. lamps are arranged for the same pressure of 100 volts, so that they can all be burnt between the same leads at the same time. The colour is in that case identical in each lamp, so that temperature differences of any great extent may be considered eliminated, and small differences at most can be present, to the disadvantage of the Edison and of the older Siemens and Halske lamps. For with identical colour taken as granted, it must be allowed that the temperature of the Siemens and Halske lamps is in consequence of this economy of 210 normal candles somewhat lower than with the Edison lamp, because this increased economy is a proof that in the Siemens and Halske lamp the radiation is relatively rich in rays of a shorter wave-length, which gives a whiter tone to the light in consequence. The Edison A lamp shows an economy of 200 normal candles per electrical horse-power when 114 volts are applied to it, which results in an intensity of 25 candles. The filament in this case, when compared with that of the new Siemens and Halske lamps at normal intensity, appears blinding white and very much overheated. Thus the new lamps give a decidedly higher economy than the older lamps or than the A lamp of Edison. The table shows that the increase in light which is afforded by the new lamps is 30 per cent of the light furnished by the same power in the older lamps. A different percentage will result upon comparing the new and old II. lamps IV. or VI. lamps together. The reason lies in the fact that the economy of the older lamps varied among themselves, which would not be the case had the temperatures been the same. Ten lamps of each sort were taken out of stock at random, and the numbers given in the table are the averages of the results of these lamps. It is no accident that the new VI. lamp has the relatively high economy of 221 nominal candles per horse-power. This type has a considerably greater cross section than Nos. II. and IV., and supports on that account a somewhat higher tension. The second step in advance which has been taken with the new lamp is to increase the resistance. In general there is nothing to prevent an increase of resistance being given, for a variety of profiles can be given to the cross section, maintaining the surface of the carbon the same. This necessitates a corresponding increase in the pressure. By means of a carbon material of excellent emissive capacity, however, it has been found possible to reach a greater resistance without changing the pressure, which is an advantage, because the working is all the steadier and better the smaller the pressure. The economy of the leads, however, depends only upon the resistance of the lamps, and not upon the pressure. Let us compare an Edison A. lamp and a Siemens and Halske IV. lamp, both at 16 normal candles, and with 100 volts of pressure. Since the A lamp requires about 30 per cent. more power than the other of the product E C (since E is the same in both) the factor C must be 30 per cent. higher. Therefore the resistance of the IV. lamp must be 30 per cent. higher than the resistance of the Edison lamp, and a different form of surface is required. The lengths of both carbons are approximately the same, while the cross section in the Siemens and Halske lamp is smaller.

It follows that the more emissive of light rays a substance is, the smaller should the cross section be made for a certain purpose and candle-power. In general this is no advantage, but Messrs. Siemens and Halske have been fortunate enough to find a material which is particularly well adapted to thin filaments, and the results as regards durability have been satisfactory.

Touching the saving in the materials of the conductors arising out of the higher resistance and the accompanying reduction in current, the effect will be different according as smaller or greater lengths of circuit are employed. The former case (of rare occurrence) arises when the strength of current alone gives the data for settling the cross section of the lead. As I pointed out in the March number of the *Electrotechnische Zeitschrift*, the diameter of the conductor is to be proportional to the current. Thus, when only half the current is necessary, the material of the leads is only one

* From the *Electrotechnische Zeitschrift*.

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quarter. With the new Siemens and Halske lamps the current is 30 per cent. less, which gives a saving in leads of over 50 per cent.

The second case occurs when the cross section must be made (on account of absorption of power in overcoming resistance) greater than if considered with respect only to the current. By increasing the resistance of the lamps 30 per cent., the cross section of the conductor can be diminished 30 per cent.

The new Siemens and Halske lamps therefore show a marked improvement in economy. Not only is the power necessary diminished by about 30 per cent., but there is also a notable lessening of the installation expenses.

ELECTRO-MOTORS AND THEIR GOVERNMENT.*

BY PROFESSORS W. E. AYRTON, F.R.S., AND JOHN PERRY, M.E.

(CONCLUDED FROM PAGE 3[illegible]0.)

We next desire to plot a curve showing how the apparent back electromotive force, e, or $V - C R_0$, divided by n, varies with the current in the De Meritens machine, but we find that this function is not independent of speed, as we have found it to be in our own motor. We have therefore assumed that the law is true, and taken an average curve for all our observations. Such a curve we find satisfies the law,

$$\frac{e}{n} = f(C) + \frac{C}{6000} + \frac{0{\cdot}0147}{C}$$

Now

$$\frac{V}{n} = \frac{e}{n} + \frac{C R_0}{n},$$

and we have already proved that

$$\frac{T}{C} = f(C) - a\,n,$$

therefore the efficiency

$$E = \frac{C f(C) - a n C}{C f(C) + \frac{C^2}{6000} + 0{\cdot}0147 + \frac{C^2 R_0}{n}}$$

where

$$f(C) = \frac{0{\cdot}002\,C}{1 + 0{\cdot}08\,C}$$

and

$$a = 0{\cdot}00000096,$$

and the power in watts usefully given out by this motor

$$P = n\,\{C f(C) - a\,n\,C\}.$$

Hence we can at once calculate both the efficiency of this motor and the power it will usefully develop when running at any speed and when any current is flowing through it.

For the purpose of ascertaining what efficiency and power can practically be obtained with motors of different makers, of various sizes, running at different speeds, and with different roads, we have made a considerable number of experiments from time to time.

The smallest motor we have tested is a Griscom motor, weighing 2½lb. A great many experiments were made, running the motor at different speeds with different loads, but the highest load or difference of weights that could be used with a dynamometer, of which the circumference was 20 centimetres, without the current dangerously heating the motor, was found to be 0·55lb., and a sample of the results so obtained is appended :—

GRISCOM MOTOR, 2½LB.

Revolutions per minute.	Current in amperes.	Potential difference at terminals in volts.	Load on dynamometer in lb.	Horse-power given in.	Horse-power given out.	Efficiency.
633	6·3	10·6	0·55	0·0891	0·00693	0·0778
1,136	6·5	12·8	—	0·112	0·0124	0·111
1,691	6·8	14·9	—	0·135	0·0185	0·137
2,120	6·7	16·4	—	1·147	0·0232	0·158
2,433	6·7	17·4	—	0·156	0·0266	0·171

Resistance of this motor when warm was 1·1 ohm.

It was found, however, at the end of these experiments, that a current of 6·7 amperes was really far too much for this motor, seeing that, had we continued the experiments, the motor would have been probably damaged. We therefore ascertained what was the greatest current that could be sent for any considerable time through this motor without injuring it, and we found that a current of about 5 to 5½ amperes was the greatest. The horse-power given out by the motor in the preceding table is therefore higher than can actually be obtained in practice, and the results contained in the following set of experiments more nearly express the normal working conditions of the Griscom motor .—

GRISCOM MOTOR, 2½LB. (Second Set.)

Revolutions per minute.	Current in amperes.	Potential difference at terminals in volts.	Load on dynamometer in lb.	Horse-power given in.	Horse-power given out.	Efficiency.
513	3·9	7·9	0·22	·0415	·00225	·0542
974	4·5	9·5	—	·0571	·00427	·0747
1,439	4·6	10·7	—	·0663	·00630	·0951
1,996	4·7	12·3	—	·0774	·00874	·113
2,520	4·9	13·3	—	·0874	·0110	·126

A useful power of about ·015 horse, with an efficiency of about 13 per cent., is the greatest that can be obtained for any length of time with the normal size Griscom motor.

The next motor in size employed was a motor with a Gramme armature and Siemens' field-magnet, weighing, with base-plates, 8·03lb. Tests were made with loads varying from 0·55 to 1·1lb. on the same dynamometer, and a sample of the results with the greatest load that could be safely employed is appended :—

GRAMME ARMATURE / SIEMENS' FIELD-MAGNET } MOTOR, 8·03LB.

Revolutions per minute.	Current in amperes.	Potential difference at terminals in volts.	Load on dynamometer in lb.	Horse-power given in.	Horse-power given out.	Efficiency.
803	16·8	8·9	1·1	0·201	0·0176	0·0876
1,200	16·8	10·0	—	0·226	0·0263	0·147
1,953	17·1	12·0	—	0·229	0·0428	0·187
2,853	16·9	13·8	—	0·314	0·0625	0·1991

Resistance of this motor when warm was 0·443 ohm.

A Jablochkoff motor, weighing 20·9lb., was the next tested, and the following results were obtained with the largest load that could be employed with a safe current :—

JABLOCHKOFF MOTOR, 20·9LB.

Revolutions per minute.	Current in amperes.	Potential difference at terminals in volts.	Load on dynamometer in lb.	Horse-power given in.	Horse-power given out.	Efficiency.
282	8·9	20·5	0·88	0·189	0·00494	0·0261
405	7·0	22·8	—	0·199	0·00711	0·0333
609	8·1	26·4	—	0·286	0·0107	0·0373
680	8·9	29·2	—	0·347	0·0119	0·0343
780	9·6	31·8	—	0·408	0·0137	0·0335

Resistance of this motor when warm was 1·17 ohm.

This motor gave, as will be seen, very small results, both as regards the power given out and the efficiency. This arises from the fact that this motor, whether regarded from an electric or from a mechanical point of view, is extremely defective in construction. When furnished to us the armature and field-magnets were in parallel circuit, but as, from the construction of the motor, during every revolution there are two places where the armature is entirely short-circuited by the brushes, it follows that this arrangement in parallel circuit is very bad. We therefore joined it up in series for our tests, but even then its bad construction, mechanically and electrically, prevented it doing more than a small amount of work, and doing it very economically.

As to the mechanical defects, the Jablochkoff motor consists of two circular coils like the coils of a tangent galvanometer placed at an angle of 45° with one another; while a third circular

* A Paper read before the Society of Telegraph Engineers, May 10, 1883.

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coil having a slightly smaller diameter than the two fixed coils revolves inside them, with its axis making an angle of 45° with the axis of rotation. As the moment of inertia of the revolving coil is very considerable there is a large couple due to the rotation, tending to diminish the angle between the axis of the coil and the axis of rotation; and this torque is so large that even at speeds of 700 revolutions we found it necessary to strengthen the mechanical connections of this coil with the axis to prevent its being pulled out of position.

Sir Wm. Thomson has lately drawn attention to the importance of placing the axis of dynamo machines on board ship parallel with the axis of the ship about which it rolls, in order to prevent undue strain being put on the bearings of the running dynamo machine when the ship rolls. But the Jablochkoff motor is so made as to put the maximum strain on the shaft when rotating.

The next motor was one with a Gramme ring and Siemens' field-magnet, weighing 30·8lb. It was of the same general construction as the Gramme motor previously tried, but not quite the same in shape—that is, the proportions of the various parts were not the same. With this larger Gramme motor various loads and various speeds were employed, as in the previous cases, the greatest load that could safely be used being 0·88lb., the circumference of the compensating dynamometer employed in experimenting with this motor being 33·3 centimetres, and larger than before. The following is a sample of the results so obtained:—

Gramme Ring / Siemens' Field-Magnet } Motor, 30·8lb.

Revolutions per minute.	Current in amperes.	Potential difference at terminals in volts.	Load on dynamometer in lb.	Horse-power given in.	Horse-power given out.	Efficiency.
932	5·4	12·8	0·88	0·0920	0·0272	·296
1,543	6·3	20·2	—	0·170	0·0451	·265
2,527	6·7	28·4	—	0·255	0·0738	·289
3,134	7·3	34·5	—	0·339	0·0916	·270
3,252	7·7	38·4	—	0·395	0·0951	·241
4,117	8·7	45·6	—	0·528	0·120	·226

Resistance of this motor when warm was 0·973 ohm.

The results given in this paper, combined with some thousands of experiments made on our normal-size motor, have led us, since reading this paper, to the means of effecting an important improvement in the direction of diminishing the magnetic friction in these moters; and, by so doing, we have been enabled to increase the power from 0·25 to 0·30 horse, and the efficiency from 30 to 40 per cent.

The following is a sample of the results obtainable with our 37lb. motor, with its field magnet made of the latest shape, and from which it will be seen that its power and efficiency both far exceed anything we have yet obtained with any other motor of about the same weight.

In the following experiments the current, and not the load, was kept constant, as we were desirous of seeing what the motor would do at various speeds when heated to the same amount.

Some Results obtained with Ayrton and Perry's Normal-size Motors, weighing 37lbs.

The circumference of the circle formed by the axis of the cord of the dynamometer used in these experiments, and shown in Fig. 28, was 3·13 feet. The columns headed W and W_1 give the weights in pounds in the two scale pans of Fig. 28.

Revolutions per minute.	Current in amperes.	Potential difference at terminals in volts.	W.	W_1.	$W-W_1$	Horse-power given in.	Horse-power given out.	Efficiency.
720	25·9	12·6	2·375	·375	2·0	·441	·14	·317
1,570	25·3	19·0	2·062	·375	1·687	·645	·241	·373
1,710	25·3	21·3	2·000	·375	1·625	·727	·266	·365
2,005	25·5	25·1	2·000	·438	1·562	·860	·297	·315
			Lead of brushes now changed.					
860	21·7	12·0	1·937	·375	1·562	·350	·127	·363
1,570	21·7	17·5	1·687	·312	1·375	·401	·204	·401
1,190	21·5	14·1	1·812	·375	1·437	·407	·162	·397
1,880	21·2	19·8	1·500	·288	1·212	·563	·215	·383

The resistance of the motor when hot was 0·2 ohm.

The following gives a *resumé* of the best working results as to power and efficiency that we have obtained with motors weighing from 2 to 500lbs.:—

Name of motor.	Weight of motor in lbs.	Horse-power actually given out.	Revolutions minute.	Efficiency.
Grisom	2·5	0·015	2,500	0·13
Gramme armature / Siemens' field-magnet.	8·03	0·0625	2,853	0·199
Jablochkoff	20·9	0·0137	780	0·0335
Gramme armature / Siemens' field-magnet.	30·8	0·0738	2,527	0·289
		0·120	4,117	0·226
Ayrton and Perry	37·	0·3	2,000	0·34
		0·2	1,570	0·40
De Meritens	72·	0·75	2,000	0·590
Siemens	519·	4·96	906	0·746
		5·60	731	0·714

We have to thank several of our students for very valuable assistance given us during the course of this investigation, but our thanks are specially due to Mr. Tomlinson for his indefatigable exertions.

A HISTORY OF ELECTRIC TELEGRAPHY TO THE YEAR 1837.

BY J. J. FAHIE, MEMB. SOC. TEL. ENGS. AND ELECS.*

Note.—Being anxious to make his History as complete as possible, the Author will be grateful to his readers for any information, no matter how small, in relation to the subjects treated of in these pages.

Chapter III.—Telegraphs Based on Static, or Frictional, Electricity.

(continued from page 383.)

1806-14.—Ralph Wedgwood's Telegraph.

The next proposal of a telegraph based, presumably, on static, or frictional, electricity is due to a member of the Wedgwood family. Ralph Wedgwood was born in 1766, and was brought up by his father at Etruria, where he received much valuable aid in chemistry, &c., from his distinguished uncle, Josiah. He afterwards carried on business, as a potter, under the style of "Wedgwood and Co." at the Hill Works, Burslem.

He appears to have early shown a genius for inventing, and while yet at Bransford had perfected many useful contrivances—amongst them, a "Pennapolygraph," for writing with a number of pens attached to one handle; and a "Pocket-secretary," since better known as the "Manifold-writer." On coming to London he found that the first-mentioned apparatus had already been invented by another person, but the second, proving to be new, he patented as "An apparatus for producing duplicates of writing."

In 1806, he established himself at Charing Cross, and soon after turned his attention to the construction of an electric telegraph, the first suggestions of which he seems to have obtained from his father.† In 1814, having perfected his plans, he submitted them to Lord Castlereagh, at the Admiralty; and after a proper interval his son, Ralph, waited on his lordship to learn his views with regard to the new invention. He was dismissed with the assurance that "the war being at an end, and money scarce, the old system [of shutter-semaphores] was sufficient for the country."

These chilling words appear to have been stereotyped, ready for use, for, as we shall see in the course of our history, they were the identical missiles with which a wearied and, perhaps, worried bureaucracy repulsed other telegraph inventors, as Sharpe and Ronalds, Porter and Alexander,‡ and goodness knows how many others besides. They certainly were the death of Wedgwood's telegraph, for he dropped it in disgust, leaving on record only a few words as to its uses and advantages—precisely such as we find them to-day. These show such an appreciation of the value of the electric telegraph, that we feel certain his own invention was of no mean order, and we must ever regret, therefore, that he has left us nothing as to its construction or

* The author reserves all rights of translation.

† According to Llewellynn Jewitt, whose "Life of Josiah Wedgwood," &c., London, 1865, we follow in this article; see Chapter IX., pp. 178-81.

‡ The writer of the article "Fifty Years' Progress" in *The Times*, January 5, 1875, says that Alexander could not hear the word "telegraph" without a shudder!

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mode of action. His remarks are contained in a pamphlet,* dated May 29, 1815; and as they are all that we have on our subject we shall quote them entire:—

"A modification of the stylographic principle proposed for the adoption of Parliament, in lieu of telegraphs, viz.:—

"The Fulguri-Polygraph, which admits of writing in several distant places at one and the same time, and by the agency of two persons only.

"This invention is founded on the capacity of electricity to produce motion in the act of acquiring an equilibrium; which motion, by the aid of machinery, is made to distribute matter at the extremities of any given course. And the matter so distributed being variously modified in correspondence with the letters of the alphabet, and communicable in rapid succession at the will of the operator, it is obvious that writing at immense distances hereby becomes practicable; and, further, as lines of communication can be multiplied from any given point, and those lines affected by one and the same application of the electric matter, it is evident from hence also that fac-similes of a despatch, written, as for instance, in London, may, with facility, be written also in Plymouth, Dover, Hull, Leith, Liverpool, and Bristol, or any other place, by the same person, and by one and the same act. Whilst this invention proposes to remove the usual imperfections and impediments of telegraphs, it gives the rapidity of lightning to correspondence *when* and *wherever* we wish, and renders *null* the *principal disadvantages* of *distance* to *correspondents*. Independent of the advantages which this invention offers to Government, it is also susceptible of much utility to the public at large, inasmuch as the offices which might be constructed for the purposes of this invention might be let to individuals by the hour, for private uses, by which means the machinery might be at all times fully occupied; and the private uses which could thus be made of this invention might be applied towards refunding the expenses of the institution and also for increasing the revenue. Innumerable are the instances wherein such an invention may be beneficially applied in this country, more especially at a time when her distinguished situation in the political, commercial, and moral world, has made her the central point of nations and the great bond of their union. To the seat of her Government, therefore, it must be highly desirable to effect the *most speedy and certain communication* from every quarter of the world, whilst it would at any moment there concentrate instantaneous intelligence of the situation of each and every principal part of the nation, as well as of each and every branch of its various departments."

In communicating the above extract to *The Commercial Magazine*, for December, 1846, pp. 257-60, Mr. W. R. Wedgwood thus urges the claims of his father to a share in the discovery of the electric telegraph:—"It may be asked, why did not Mr. Ralph Wedgwood carry his invention into practical application? The answer is very obvious. Railways were not then in existence, and the connecting medium required an uninterrupted course such as railways alone afford. Such an invention also required the assistance either of Government or a powerful company, the scheme being too gigantic for an individual to work. The inventor, then, it will be perceived, did all that was possible to bring the discovery into practical use; for, in the first instance, he offered it to the Government, who refused it; and, as it was for the benefit of the nation, he then made public his scheme of an electric telegraph in the manner quoted from his pamphlet."

1816.—Ronalds' Telegraph.

This ingenious contrivance belongs to the synchronous class of telegraphs, of which we have already seen two other examples, viz., those of Chappe, 1790, and Alexandre, 1802. It is, in fact, only the realisation of Chappe's idea. Sir Francis (then Mr.) Ronalds took up the subject of telegraphy in 1816, and pursued it very ardently for some years, until, like Wedgwood, disgusted with the apathetic conduct of the Government, he dropped the matter, and, more in sorrow than in anger, took leave of a science which, as he says, was up to that time a favourite source of amusement. Fortunately for the science, he returned to his old love in later years, and, dying August 8, 1873, left us a grand legacy in the Ronalds' Library.†

In 1823, he published a thin octavo volume, entitled "Descriptions of an Electrical Telegraph, and of some other Electrical Apparatus;" and, in 1871, the original work having become very scarce, he issued a reprint of the part relating to his telegraph. From this, in accordance with our rule of consulting, when possible, original sources, we extract the following account. Through the kindness of our friend, Mr. A. J. Frost, we are enabled to illustrate our article with the original copper-plates which were engraved from Ronalds' own sketches, in 1823. These illustrations the Editor has decided to issue in the form of a Supplement to this week's issue.

Ronalds begins by saying:—"Some German and American savans first projected galvanic, or voltaic, telegraphs, by the decomposition of water, &c. But the other [or static] form of the fluid appeared to me to afford the most accurate and practicable means of conveying intelligence; and, in the summer of 1816, I *amused* myself by wasting, I fear, a great deal of time, and no small expenditure, in trying to prove, by experiments on a much more extensive scale than had hitherto been adopted, the validity of a project of this kind."

These experiments were carried out on a lawn, or grass-plot, adjoining his residence at Hammersmith, and as, of course, it was impossible to lay out in a straight line a great length of wire in such a situation he had recourse to the following expedient: Two strong frames of wood (*see* Supplement) were erected at a distance of 20 yards from each other, and to each were fixed nineteen horizontal bars. To each of the latter, and at a few inches apart, were attached thirty-seven hooks, from which depended as many silken loops. Through these loops was passed a small iron wire, which, going from one frame to the other, and making its inflections at the points of support, formed one continuous length of more than eight miles.

When a Canton's pith-ball electrometer was connected with each extremity of this wire, and it was charged by a Leyden jar, the balls of both electrometers appeared to diverge at exactly the same moment; and when the wire was discharged, by being touched with the hand, they both collapsed as suddenly and, as it appeared, as simultaneously. When any person took a shock through the whole length of wire, and the shock was compelled to pass also through two insulated inflammable air pistols, one connected with each end of the wire, the shock and explosion seemed to occur at the same instant.

When the spark was passed through two gas pistols, and any one closed his eyes, it was impossible for him to distinguish more than one explosion, although both pistols were, of course, fired. Sometimes one, and sometimes both, pistols were feebly charged with gas, but nobody, whose back was turned, could tell from the report, except by mere chance, whether one or both were exploded.

Thus, then, three of the senses, viz., sight, feeling, and hearing, seemed to receive absolute conviction of the instantaneous transmission of electric signs through the pistols, the eight miles of wire, and the body of the experimenter (pp. 4 and 5).

Accepting these experiments as conclusive of the practicability of an electric telegraph, Ronalds next sought out the best means of establishing a communication between any two distant points; and, after trying a number of ways, at last adopted the following, as being the most convenient. A trench was dug in the garden, five hundred and twenty-five feet in length, and four feet deep. In it was laid a trough of wood, two inches square, and well lined, inside and out, with pitch. In the trough thick glass tubes were placed, through which, finally, the wire (of brass and copper) was drawn. The trough was then covered with strips of wood, previously smeared with hot pitch, and, after painting with the same material the joints, so as to make assurance doubly sure, the trench was filled in with earth. Fig. 1 represents a section of this trough, tube, and wire. It will be seen that the different lengths of tube A, B, C, did not touch, but that at each joint, or rather interval, other short tubes, or ferrules, D, E, were placed, of just sufficient diameter to admit the ends of the long ones, together with a little *soft* wax. This arrangement effectually excluded any moisture, and yet left the parts free to expand and contract with variations of temperature.

The apparatus for indicating the signals, and its *modus operandi* are thus described:—A light, circular brass plate, Fig. 2

* Entitled "An Address to the Public on the Advantages of a proposed introduction of the Stylographic Principle of writing into general use; and also of an improved species of Telegraphy, calculated for the use of the Public, as well as for the Government." It will be found at the end of his "Book of Remembrance," which was published in London, 1814. Wedgwood was an exceedingly reticent man, and, it is feared, carried with him to the grave other scientific secrets, as well as that of the telegraph. He died at Chelsea in 1837.

† A magnificent collection of books on electricity, magnetism, and their applications. The catalogue compiled by Sir Francis is a monument of the concentrated and well-directed labour of its indefatigable author. It has been ably edited by Mr. A. J. Frost, and published at an almost nominal price by the Society of Telegraph-Engineers and Electricians. No student of electricity should be without it. A short, alas! too short, biography of Sir Francis by the editor is prefixed to the catalogue, to which we refer our readers for much interesting information. We would here correct an error—the only one we believe—into which the biographer has fallen. On page xv. he says:—"Wheatstone, then a boy of about 15, was present at many of the principal experiments at Hammersmith." Wheatstone was born at Gloucester in 1802, where he lived until the year 1823, when he came up to London, and opened business as a maker of musical instruments. It seems impossible to us that a poor lad of 14, as Wheatstone was in 1816, could have been present at Ronalds' experiments, even supposing that he was not then living far away in Gloucester.

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divided into twenty equal parts, was fixed upon the seconds' arbor of a clock which beat dead seconds. Each division bore a figure, a letter, and a preparatory sign. The figures were divided into two series, from 1 to 10, and the letters were arranged alphabetically, leaving out J, Q, U, W, X, and Z, as of little use. In front of this disc was fixed another brass plate, Fig. 3, capable of being occasionally revolved by the hand round its centre. This plate had an aperture of such dimensions, that, whilst the first disc, Fig. 2 was carried round by the motion of the clock, only one set of letter, figure, and preparatory sign could be seen, as shown in the figure. In front of this pair of plates was suspended a Canton's pith-ball electrometer, B, Fig. 4, from an insulated wire, C, which communicated with a cylindrical machine, D, of only six inches' diameter, on one side; and with the line wire, E, insulated and buried in the way just described, on the other.

Another electrical machine and clock, furnished with an electrometer and plates, being connected to the other end of the line in precisely the same way, it is easy to see, that when the wire was charged by the machine at *either* end, the balls of the electrometers at *both* ends diverged; and that when the wire was discharged at either station, both pairs of balls collapsed at the same time. Whenever, therefore, the wire was discharged at the moment that a given letter, figure, and sign of one clock appeared in view through the aperture, the same letter, figure, and sign appeared also in view at the other clock; and thus, by discharging the line at one end, and by noting down whatever appeared in view at every collapse of the pith balls at the other, any required words could be spelt. By the use of a telegraphic dictionary, the construction of which is explained at pages 8 and 9 of Ronalds' little treatise, words, and even whole sentences, could be intimated by only three discharges, which could be effected, in the shortest time in nine seconds, and in the longest in ninety seconds, making a mean of fifty-four seconds.

Whenever it was necessary to distinguish the preparatory signs from the figures and letters, a higher charge than usual was given to the wire, which made the pith balls diverge more widely; and it was always understood that the first sign, viz., *prepare*, was intended when that word, the letter A, and the figure 1, were in view at the sender's clock. Should, therefore, the receiver's clock not exhibit the same sign, in consequence of its having gained, or lost, some seconds, he noted the difference, and turned his outer plate, Fig. 3, through as many spaces, either to the right or left, as the occasion required, the sender all the while repeating the signal, *prepare*. As soon as the receiver had adjusted his apparatus, he intimated the fact by discharging the wire at the moment when the word *ready* appeared through the opening. In order to indicate when letters were meant, when plain figures, and when code figures referring to words and sentences in the dictionary, suitable preparatory signs were made beforehand, as *note letters*, *note figures*, and *dictionary*. Other preparatory signs of frequent use were marked on the dials, and were designated in the same manner whenever required.

The gas pistol F, Fig. 4, which passed through the side of the clock-case G, was furnished with a kind of discharging-rod, H, by means of which a spark might pass through and explode it when the sender made the sign *prepare*. This obviated the necessity of constant watching on the part of the attendant, which was found so irksome in the semaphores of those days. By a slight turn of the handle, I, the attendant could break the connection between the line wire and the pistol, and so put his apparatus into a condition to "receive."

Midway between the ends of the wire was placed the contrivance, *k*, *k*, Fig. 4, by which its continuity could be broken at pleasure, for the purpose of ascertaining (in case any accident had happened to injure the insulation of the buried wire) which half had sustained the injury, or if both had. It is seen that the two sides of the wire were led up into the case, and terminated in two clasps, L, and M, which were connected by the metal cross piece, N, carrying a pair of pith-balls. By detaching this wire from the clasp L, whilst it still remained in contact with M, or *vice versâ*, it could at once be seen which half of the wire did not allow the balls to diverge, and, consequently, which half was damaged, or if both were.

One of the stations of this miniature telegraph was in a room over a stable, and the other in a tool-house at the end of the garden, the connecting wire being laid under the gravel walk.*

Having made a large number of experiments with this line, and having thoroughly proved the practicability of his invention, Ronalds decided upon bringing it to the notice of the Government. This he did on the 11th of July, 1816, in a letter addressed to Lord Melville, the First Lord of the Admiralty, as follows :—

"Mr. Ronalds presents his respectful compliments to Lord Melville, and takes the liberty of soliciting his lordship's attention to a mode of conveying telegraphic intelligence with great rapidity, accuracy, and certainty, in all states of the atmosphere, either at night or in the day, and at small expense, which has occurred to him whilst pursuing some electrical experiments. Having been at some pains to ascertain the *practicability* of the scheme, it appears to Mr. Ronalds, and to a few gentlemen by whom it has been examined, to possess several important advantages over any species of telegraph hitherto invented, and he would be much gratified by an opportunity of demonstrating those advantages to Lord Melville by an experiment which he has no doubt would be deemed decisive, if it should be perfectly agreeable and consistent with his lordship's engagements to honour Mr. Ronalds with a call; or he would be very happy to explain more particularly the nature of the contrivance if Lord Melville could conveniently oblige him by appointing an interview.

"Upper Mall, Hammersmith, July 11, 1816."

Lord Melville was obliging enough, in reply to this communication, to request his private secretary, Mr. Hay, to see Ronalds on the subject, but before an interview could be arranged, and while the nature of his invention was yet a secret, except to Lord Henniker, Dr. Rees, Mr. Brand, and a few particular friends, he received an intimation from Mr. Barrow, the Secretary of the Admiralty, to the effect that telegraphs of any kind were then wholly unnecessary, and that no other than the one then in use (the old Semaphores of Murray and Popham) would be adopted. This much-quoted, and now historic *communique* ran as follows* :—

"Mr. Barrow presents his compliments to Mr. Ronalds, and acquaints him, with reference to his note of the 3rd inst., that telegraphs of any kind are now wholly unnecessary, and that no other than the one now in use will be adopted.

"Admiralty Office, 5th August."

In reference to this correspondence Ronalds says :—"I felt very little disappointment, and not a shadow of resentment, on the occasion, because every one knows that telegraphs have long been great bores at the Admiralty. Should they *again* become *necessary*, however, perhaps electricity and electricians may be indulged by his lordship and Mr. Barrow with an opportunity of *proving* what they are capable of in this way. I claim no indulgence for mere chimeras and chimera framers, and I hope to escape the fate of being ranked in that unenviable class" (p. 24).

Ronalds will always occupy a high position in the history of the telegraph, not only on account of the excellence and completeness of his invention, but also for the ardour with which he pursued his experiments, and endeavoured to bring them to the notice of his contrymen.† Had he worked in the days of railways and joint-stock enterprise, there can be no doubt that his energy and skill would have triumphed over every obstacle, and he would have stood forth as the practical introducer of electric telegraphs; but he was a generation too soon, the world was not yet ready for him.

His little *brochure* of 1823 is the first work ever published on the subject of electric telegraphy, and is so marvellously complete that it might almost serve as a text-book for students at the present day. In it he proposes the establishment of telegraph offices throughout the kingdom, and points out some of the benefits which the Government and public would derive from their existence. "Why," he asks "has no *serious trial* yet been made of the qualifications of so *diligent* a courier? And if he should *be* proved competent to the task, why should not our kings hold councils at Brighton with their ministers in London? Why should not our Government govern at Portsmouth almost as promptly as in Downing-street? Why should our defaulters escape by default of our foggy climate? and, since our piteous inamorati are not all Alphei, why should they add to the torments of absence those dilatory tormentors, pens, ink, paper, and posts? Let us have *electrical conversazione offices*, communicating with each other all over the kingdom *if we can*."‡

It would hardly be possible at the present day to describe more

* After a lapse of nearly fifty years, a portion of this line was dug up, in 1862, in the way described in Frost's "Biography," page xviii. Some years later the specimen came into the possession of Mr. Latimer Clark, by whom it, as well as the original dial apparatus, was exhibited at the Special Loan Collection of Scientific Apparatus, South Kensington Museum, 1876, and at the late Electrical Exhibitions in Paris and London (Crystal Palace). They may now be seen in the British Section of the Vienna Exhibition.

* The originals of these important documents, with many other valuable papers, relating to this subject, may be consulted in the Ronalds' Library. See page 439 of the Catalogue.

† It might have been with a knowledge of Ronalds' telegraphic experiments that Andrew Crosse, in 1816, uttered the prophecy, with which his biographer opens the story of his life :—"I prophesy that by means of the electric agency we shall be enabled to communicate our thoughts instantaneously with the uttermost ends of the earth."—"Memorials Scientific and Literary of Andrew Crosse, the Electrician," London, 1857.

‡ Pages 2-3. It is curious to note the similarity of ideas on this subject that occurs in the extract, which we have given, on another page, from

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accurately the progress of electric telegraphy than in these characteristic sentences. We have "electrical conversazione offices" all over the kingdom. The wires which connect Balmoral, Windsor, and Osborne with Downing-street, enable Her Majesty to "hold councils with her Ministers in London" at any moment; while the extensive system of Admiralty and War Office telegraphs enables the Government to "govern at Portsmouth [and many places besides] as promptly as in Downing-street." One of the very first acts of the very earliest telegraph was the capture of Tawell, the Quaker murderer; and the curious ramification of police telegraphy in London, if not an absolute protection against our "foggy climate," is, at least, a terror to those who might otherwise elude the grasp of the law. As for our "piteous inamorati," it is perfectly well known that they use the wires as freely as most people, and that "love telegrams" are gradually taking the place of "love letters."

His underground wire was a fair specimen of what exists at the present day. We use iron, or earthenware, pipes in lieu of his wooden trough; but we are not very far in advance here, for he points out by way of anticipating possible objections to his plan, that "cast-iron troughs might be rendered as tight as gas-pipes," should it be deemed desirable to employ them. He did not recommend his glass tube insulators to the exclusion of all other methods, as, for example, that of Cavallo, by means of pitch and cloth. "No person," says he, "of competent experience in these matters will doubt, that either of them, or several other plans that might be chosen, would be efficient. But since accident and decay compose the lot of all inanimate, as well as animated nature, let two or more sets of troughs, tubes, and wires be laid down; so that, whilst one may be undergoing repair, the others may be ready for use" (page 16).

On the general question of conservancy he says:—"To protect the wire from mischievously disposed persons, let the tubes be buried six feet below the surface of the middle of high roads, and let each tube take a different route to arrive at the same place. Could any number of rogues, then, open trenches six feet deep, in two or more public high roads or streets, and get through two or more strong cast iron troughs, in a less space of time than forty minutes? for we shall presently see that they would be detected before the expiration of that time. *If they could*, render their difficulties greater by cutting the trench deeper: and should they still succeed in breaking the communication by these means, hang them if you can catch them, damn them if you cannot, and mend it immediately in both cases. Should mischievous devils from the subterranean regions (*viz.*, the cellars) attack my wire, condemn the *houses* belonging thereunto, which cannot *easily* escape detection by running away" (page 17).

Ronalds, however, proposed to rely upon other means than Lynch law in maintaining his communications, and here, again, the telegraph engineers of the present day have followed out his ideas almost to the letter. He proposed to keep his wire constantly charged with electricity, then to have certain proving stations (like that described a page or two back) at frequent intervals along the line; and a staff of persons who would constantly watch the provers, and set out the moment that any indication of an interruption was given. Suitable situations for such proving stations he conceived to be "post-offices in towns and villages, turnpike gates, and the like."

"To put a simple case: we will imagine twenty proving stations established between London and Brighton, or any distance of fifty miles, only four persons employed (but not exclusively) to keep watch over them, and each watchman to have charge of five provers. It is evident that (were he to dwell at the centre one of the five), in order to examine the two on each side of it, he would have to ride only four miles and eight-tenths, which journey even our twopenny post-boy could perform in something less than forty minutes; and he would discover that the defect rested somewhere between two of the provers, a distance of two miles and four-tenths. Let him report his discovery accordingly to the engineer, who may open the trench and the trough at mid-distance of this two miles and four-tenths, make an experiment upon the wire itself similar to that of the provers, and, when he has discovered which half is defective, operate upon that half in the same way. Thus proceeding continually, he must arrive, after ten bisections, within about three yards of the defect" (pages 19, 20).

Now, what are these innumerable "flush-boxes" which are to be found everywhere in the streets of London and other large cities but "provers" of our underground telegraphic system? Most people are familiar with the snake like coils of telegraph wires, which are every now and then laid bare in those curious apertures in the pavement, and the little clock-face, with a single handle, which is the invariable companion of the workman engaged in the hole. He is simply "proving" a wire which has been found faulty. Then, again, as regards overhead wires, what are the "linemen" stationed at certain intervals along the route of a trunk line but the "provers" of the section which it is their duty to traverse from time to time, working on either side of their station, precisely as Ronalds would have worked his "sorry little twopenny post cove?"

Referring to the difficulty that had been urged of keeping the wire charged with electricity, Ronalds says, on page 21:—"As to sufficiency (I have no dread of the charge of vanity in borrowing a boast from the great mechanic), give me *materiel* enough, and I will electrify the world. The Harlem machine would probably *in time* electrify, sufficiently for our purpose, a wire circumscribing the half of England: but we want to *save* time; therefore let us have a small steam engine, to work a sufficient number of plates to charge batteries, or reservoirs, of such capacity as will charge the wire *as suddenly* as it may be discharged when the telegraph is at work; and when it is *not* at work, let the machine be still kept in gentle motion, to supply the loss of electricity by default of insulation; which default, perhaps, could not be avoided, because (be the atmosphere ever so dry, and the glass insulators ever so perfect) conductors are, I believe, robbed of their electricity by the same three processes by which Sir Humphrey Davy and Mr. Leslie say that bodies are robbed of their sensible heat, *viz.*, by radiation, by conduction, and by the motion of the particles of air."

While freely admitting that electro-magnetism was much better adapted to the purposes of telegraphy, Ronalds maintained to the last the practicability of his own plans. In a letter to Mr. Latimer Clark, dated Battle, 9th Dec., 1866, he thus writes:—"Had the necessary steps been taken in 1816 to provide a tensional electric telegraph for Government and general purposes, such an instrument might have been constructed and usefully employed, and might have been greatly improved after the so-called Oersted discovery.* * * *

"Do we not all know that an electrophorus (of glass or resin) will remain charged, even when both opposed metallic surfaces are in conducting communication, and can *you* not believe that my difficulty of discharging my wire was greater than that of preserving a charge? * * *

"I could always supply as much electricity as might be wanted for any length of my telegraphic wire, and it did *not fail*, as many very respectable witnesses well know. I did not (properly speaking) discharge the wire so much as to cause the electrometer [balls] to collapse, the threads merely vibrated sufficiently to designate a sign when the wire was touched by a rapid stroke."†

(TO BE CONTINUED.)

Ralph Wedgwood's pamphlet of 1815. The two trains of thought are perfectly independent, for we believe that Ronalds knew nothing of Wedgwood's invention—a conclusion to which we are led by the absence of his name from the Ronalds' catalogue.

* In the way, for example, suggested in the following extract from Mr. (afterwards Sir) W. F. Cooke's letter to Ronalds, of 11th December, 1866:—"I have often thought what a fortunate thing it would have been if I had known of your labours in 1837. The letters of the alphabet, three letters in a row, might have been distinguished on your clocks by a movement of a needle to the left [for, say, the outer letter], the middle letter by a flourish of the needle right and left, and the inner letter by a movement of the needle to the right." See Ronalds' MSS.

† Extracted by kind permission of Mr. Latimer Clark.

MEDITERRANEAN EXTENSION TELEGRAPH COMPANY (LIMITED).

An extraordinary general meeting of this Company was held on Monday, at the Cannon-street Hotel, the Hon. Ashley Ponsonby in the chair.

Mr. Edward Tombs (the secretary) having read the notice convening the meeting,

The Chairman said: Well, gentlemen, I am in the unfortunate position of being your only director. Since we had the pleasure of meeting you we have lost our late chairman, Sir James Carmichael, and Mr. Robinson, and I feel sure I am expressing your views when I express our great sorrow at the loss of our chairman. We all knew him for many years to be a chairman who gave his attention entirely to the interest of your Company. He was genial, he was kind, and he acted to the best of his abilities, I am sure you will all confess, but at the same time we must feel that, as at this meeting to-day we have a resolution to propose for the winding up of the Company, it is almost a pleasant thing for him not to know what was going to take place, seeing the great interest he took in your affairs. In Mr. Robinson I have lost a great friend and able colleague, and although I did not know him so long as Sir James, yet I knew him to be a business man, and a man of great energy in your service, and I am sure you will hear with great regret that I have to tell you he is no more. Now, gentlemen, we are met to-day for the purpose of considering a petition that has been presented by Mr. Hurst, from whom you have received many circulars. He has a considerable standing in the Company, holding 300 shares. He was of

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opinion that the Company should be wound up compulsorily, and I have to warn you that if you adopt his views you will probably have very little to receive for yourselves. I am sure you know, and experience shows, that compulsory winding up leaves little for the shareholders, and not even much for the creditors, and therefore, gentlemen, I thought it advisable to take upon myself, although placed in——

Mr. ATWELL: Excuse my interrupting you, sir, but who is Mr. Hurst?

The CHAIRMAN: He holds 300 shares.

Mr. ATWELL: What is he?

The CHAIRMAN: He is a stockbroker.

Mr. ATWELL: I thought so. How long has he been a shareholder?

The CHAIRMAN: That I do not know. I can only tell you the facts.

Mr. ATWELL: That is what I wanted to know. It is what I expected.

The CHAIRMAN: Mr. Hurst is, no doubt, right in his opinion that the Company should be wound up. We are not able to pay the interest to our preference holders, as I will show you afterwards, and it is better that the Company should not go on till all its assets are wasted and there is nothing for the shareholders. My own objection to what Mr. Hurst wishes is that it should be compulsory; I prefer it should be done in a voluntary manner. That is the reason I took upon myself, although I had no authority, being one director, and not able to have a Board, or even appoint a provisional director, or even call you together, to instruct our solicitor to move the Court for the postponement of the petition until your views had been taken. The petition has been postponed until November, and now comes the point—for really I have very little to say to you to-day—whether the winding up should be compulsory or whether it should be voluntary. Now, since the death of Sir James I have been negotiating to the best of my ability with a certain company for the purpose of buying up our concern. They were, in fact—I suppose I may say so, because they know it as well as I do—they were, in fact, the only company that could buy it. I was met with difficulties to a certain extent, and I am sorry to say I was not able to receive as large an offer as was proposed to you in November last, but at the same time I think it is an offer which it would be well, when the time comes, for the shareholders to consider whether it would not be wise for them to accept. You must be aware that our receipts for the last five years ending in 1882 were £22,220, giving a yearly average of £4,444.

Mr. BURT: Does that include the subsidies?

The CHAIRMAN: No. Those were the receipts of the Company. The gross expenditure at Malta and Corfu for those five years was £10,531, giving an annual average of £2,106. That did not include our home expenditure, which varies as you see in your accounts about £1,000 a year, or, putting it at £900, there is an average total yearly expenditure of £3,000. If you take £3,000 from £4,440 you remain with £1,444 to the good. That £1,444 will not meet the interest on our preference holders, because £32,000 at 8 per cent. you will see requires £2,560, therefore there was nothing left for the repair of the cable, there was nothing left for the reserve fund, and there was nothing left for working expenses, therefore I thought I was justified in trying to do my best to obtain an offer for the purpose of purchasing our lines and our concessions. You must remember also our cables are one year older, and our concession one year shorter than when that offer was made in November, and therefore, taking the whole into consideration, I thought the wisest plan was to effect a sale. These papers will be submitted to the shareholders for their consideration as soon as the preliminaries have been further settled; yesterday was the last day I got my terms fixed. Well now, gentlemen, therefore it comes to this—whether it is to be a voluntary or whether it is to be a compulsory winding up. I have placed in my hands a resolution: "That the Company be wound up compulsorily by the order of the Court, in compliance with the terms of the petition presented by Mr. Francis Hurst of No. 7, Drapers'-gardens, in the City of London, stockbroker."

Mr. HURST: I understand, Mr. Chairman, you have a majority of proxies, but I think the whole thing is in a narrow compass. We all agree that we must wind up; it is merely a question whether it shall be voluntary or compulsory. Being a shareholder myself I have not the slightest wish to put the Company to any expense, and if it could be agreed upon to wind up in a voluntary manner I do not wish my resolution to be put.

Mr. ATWELL: Do you withdraw it?

Mr. HURST: I shall withdraw the resolution.

Mr. ATWELL then moved that the Company be wound up voluntarily, under the provisions of the Companies' Acts 1862 and 1867.

Mr. PARNELL having seconded the motion,

Mr. ATWELL continued that, considering the unfortunate position the Company was placed in, there was no alternative but to wind up.

The motion was then put and carried.

Mr. VEARS asked whether this put it in the power of the liquidators to accept the offer to which the chairman had alluded.

The CHAIRMAN replied that of course the shareholders would first be asked whether they would accept any offer or not.

Mr. ATWELL then moved, "That the Hon. Ashley Ponsonby, a director of the Company, and one other shareholder, to be nominated at the meeting, be appointed liquidators for the purpose of such winding up, and that the remuneration to be paid to such liquidators shall be left to the decision of the shareholders at a future meeting."

Mr. VEARS seconded the motion.

Mr. ATWELL said that he did not think they could do better than appoint the Hon. Ashley Ponsonby, because the gentleman had been connected with the Company for some time, and must know more about it and what its value was than any outsider.

Mr. GOULD pointed out that there were two classes of shareholders, the original and the preference, whose capital some years ago saved the concern. They had, in fact, been carrying on the operations of the Company for a great number of years upon the strength of the capital subscribed by the preference holders, and he thought it would be an act of grace and courtesy to them that one of the liquidators should represent the preference shareholders. No doubt very grave questions would arise as to the claims of the two classes of shareholders. His own impression was that the matter would involve difficulties which the liquidators would hardly like to take upon themselves to settle, and therefore he thought the preference shareholders had a claim upon this meeting for one of their number to be appointed.

The SOLICITOR said that only one question could arise, and that was as to the respective rights of the preference and original shareholders, and that would have to go before the chief clerk, and he was quite sure justice would be done to both classes.

The CHAIRMAN said that if he were appointed liquidator, of course he would do his best for both parties. He should act under the advice of the Court and the solicitor.

In reply to a question,

The CHAIRMAN said he had no objection to appoint a preference shareholder.

Mr. BURT called attention to the form of the notice that they could only appoint one other shareholder.

Mr. HURST did not think it mattered whether the liquidators were preference or ordinary shareholders.

The motion was then put and carried, and Mr. Griffiths (Deloitte, Dever, Griffiths, and Co.) was appointed the other liquidator.

A vote of thanks to the chairman terminated the proceedings.

THE GREAT WESTERN ELECTRIC LIGHT AND POWER COMPANY (LIMITED AND REDUCED).

The first ordinary general meeting of this Company was held on Monday, at the Cannon-street Hotel, Mr. Braithwait, jun., in the chair.

Mr. ALEX. SMITH (the Secretary) read the notice convening the meeting, and the report of the directors was taken as read.

The CHAIRMAN said that in meeting the shareholders on the first occasion since he and his colleagues took office they had not perhaps a very pleasant task to perform, inasmuch as they had not a balance-sheet showing an actual profit on the operations of the Company; at the same time it had been their endeavour to hasten the period when such a result should be shown. They had succeeded in materially reducing the working expenses of the Company, and they had also effected an increase in their income from the lighting stations, and hoped to meet on a future occasion under more favourable circumstances. They had only had charge of the affairs of the Company for about two months, and they had been unable to do much to reverse the policy of their predecessors, as most of the expenditure had been incurred before the present directors took office. He might, however, say that during those two months they had raised the income of their lighting stations considerably more than 100 per cent. They had considerably more than doubled their income from the stations at Bristol and Cardiff, while at the same time they had effected such reductions in the working expenditure, that, as far as they could judge, they considered that those stations were now paying their way, and they hoped before the end of this winter to have additional contracts which would yield a profit. The legal difficulties with which the Company was surrounded when they came into office they had not succeeded in entirely dispelling. At that time there was a large number of shareholders taking actions against the Company, with the view of obtaining repayment of the money paid on their shares. The late directors repaid a great many, and the present Board took steps to settle the remaining claims as rapidly as possible. They had obtained 941 shares from various gentlemen at a cost of £274. That did not include their own costs, which were included in the law charges. They had tried to place the affairs of the Company before the shareholders in the clearest possible light, and to make the balance-sheet as plain as possible. The net result was a loss of £3,801, and that was owing to the high rate of expenditure. They had reduced the expenditure under general charges to £545, and the salaries and wages had been reduced to between £700 and £800. On the basis of the Company as they were now working, and with the present fixed charges, the result of the transactions, instead of showing a loss, would have shown a profit of £1,100. The increasing charges of the Company on the present basis were about £1,100 a year, and if they only succeeded in doing as much business in the coming year as in the past, they would be about £1,500 to the good at the end of the year. The income from the lighting stations he hoped would materially improve. Since the date of the report they had had several additional contracts. In Bristol and Cardiff they had sufficient plant to meet all the requirements that could arise in regard to electric lighting. At Cardiff they were lighting several shops and one newspaper office. The rates they were charging compared very favourably with gas. One company was willing to supply the electric light at a rate equivalent to 7s. 6d. per 1,000 feet of gas, and another was willing to supply it at 5s. That was the Swan, but he should be glad if they were to receive anything like the equivalent rates of gas, even if it were as low as 2s. 8d. per 1,000 feet. If they had any other system than the Brush they would not be able to supply the electric light at anything like the price of gas. At that price they considered it left them a very handsome and working profit if they had their engines regularly employed, working up to their full capacity. In that case they estimated that each of the lighting stations would return about 30 per cent. on the capital employed. Arrangements had been made with the Electric Light, Power, and Storage Company to act as agents of that company for the sale of their accumulators. Any company would be incomplete which could not supply accumulators. In their lighting stations it would enable them to practically double the capacity of their plant. It became important to see whether there was any accumulator in the market which was a practical one, and which might be said to be a commercial one, and they could only find one which was in the market at all, and that was the one supplied by the Electric Light, Power, and Storage Company. They therefore made some inquiries as to what it could do; in fact, he made experiments in his own house. He found it work successfully, and that it was in use in many places in London, including a large steam shipping office, so that it appeared there was something beyond the mere stage of experiment. They had not paid any money, but on all the accumulators they would get a good trading profit, and that enabled them to carry out any electric lighting that could possibly be required of them. With regard to the balance-sheet, the trade loss was £3,800, but owing to the money received from the sale of the Devon and Cornwall concessions, £7,500, they still had some cash in hand, after writing off 500 shares as having no value whatever, likewise the shares received in part payment of the concession. They did not think they should put any value on them, as the company

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was in liquidation. There was a balance left of £2,500, and the question arose what they should do with it? Should they devote it to writing off the value of the concession? They came to the conclusion that if they did that it would be merely a question of book-keeping, inasmuch as the expense of the law proceedings in connection with the Lane-Fox and Devon and Cornwall would have to be paid sooner or later, and therefore they thought they would be doing the best thing for the Company if they applied the surplus to the wiping out of these extraordinary expenses, so as to enable them to start with a clean balance-sheet. They had written off the whole of the law charges, although none of the bills were taxed; they had also written off the whole of the expenses in connection with the Devon and Cornwall, and written down their plant to the current rates, which involved writing off the £700 or £800. When the Company was started the prices charged by the Anglo-American Brush Company were considerably higher than now, so that they had written down the cost, and they considered that they had now fair value to show. They had been unable to write anything off the value of the concessions purchased, but were fully aware of the importance of doing this, seeing that the patents had only 11 years to run. He was not without hopes that they might be able to induce the parent company to surrender some of the fully-paid vendors' shares, but they had still paid £20,000 in hard cash for their concessions, and they ought to wipe that out at the rate of £2,000 a year. The freehold and leasehold land at Bristol and Cardiff they considered a good asset at the price in the balance-sheet. At Bristol their property was freehold, and at Cardiff it was leasehold with 29 years to run. They had put £300 a side for bad and doubtful debts as a matter of precaution, as there were one or two bills overdue amounting to £282, but the necessary steps were being taken to recover the money. He thought he might say they had put down every possible liability which there was against the Company, and they had taken the assets at as fair a valuation as they could, while the concession was necessarily bought in at the price they gave for it. In the profit and loss account the most striking item was the heavy expenses incurred by the late board—£5,278. The rates and taxes they had reduced to about half the former amount. They had given up their London office, and had taken an office which would cost about a quarter of the money. They had given up the office at Bristol, and all the business was now done at the lighting station. The salaries and wages would also be reduced to half the amount. The printing and stationery (£227) included the outfit of the Company in the way of books, ledgers, &c., so that that item was not likely to occur again. In the directors' fees and travelling expenses in future there would be a great reduction. He might mention what their intentions were with regard to the directors' fees. His colleagues and himself, after looking at the matter very carefully, had come to the conclusion they ought to take no fees whatever up to the date of the present balance-sheet, and during the current year it was their intention to draw one half what the Articles of Association allowed them to draw, namely £500, instead of £1,000, and they trusted the business they would do would be well worth the money. The large amount of travelling expenses hitherto was owing to the directors being scattered all over the country. Occasionally the present Board might have to go to Bristol or Cardiff to inspect their stations, but he thought that out of the late expenditure of £650 they would effect a saving of £500. With regard to their prospects for the coming year, two months had already elapsed, and during that time they had not been able to do what they would have liked to have done, chiefly owing to the delay in the publication of the new pamphlet the Anglo American Brush were bringing out. The Brush Company had made great improvements in their incandescent lamps, and he hoped that their pamphlet would be published in a very short time, and as soon as that was done they would be able to set to work. With regard to the Devon and Cornwall, the moment that company commenced to go into liquidation their district reverted to this Company, and therefore they were in a position to work it again. They would make a beginning on the 16th of this month with a sixteen-light installation to light the Ilfracombe Hotel, and he hoped that their agent would be able to do something in that neighbourhood, for the water power which was available there was one of the most hopeful features in the whole of their district, and it very much reduced expenses. Another source from which they ought to derive a profit was the sale of isolated installations, which was the most satisfactory branch as far as they were concerned, because it did not employ any of their capital. They made their charge, got their money and pocketed their discount, and there was an end of the transaction. He thought in the coming winter there would be more done in that way than there was last year. There had been more inquiries for electric lighting the last three weeks than in the whole of the previous time the present Board had been in office. In conclusion the chairman moved the adoption of the report and accounts.

Mr. REYNOLDS seconded the motion. He said that the Company declined all work that was offered them at an unremunerative price, and he thought they would be able in a short time to bring the Company into a paying state. There could be very little doubt about the economy of the Brush dynamo. In the Severn Tunnel one of their 40-light dynamos had been working 23 hours out of the 24 without a single break down. He thought that that was a marvellous fact that they could work at night with these lights with only one hour's rest out of the 24. He did not think the Americans would have adopted the Brush machine if they had not been convinced it was the most economical. Every thing the present Board could do to bring the Company into a paying state would be done.

Mr. OFFER thought they must all be satisfied that they had a business Board. Whatever the result to the Company might be, they were under good management. He believed that when the electric light could be supplied in as simple a form as gas there would be a great demand for it.

In reply to questions,

The CHAIRMAN said the liquidation of the Devon and Cornwall had not made sufficient progress to enable them to say whether there was a likelihood of a further call. He should imagine not, as there was a considerable amount of cash in hand, therefore their liability under the shares they held was a very remote contingency. With regard to not having provisional orders, he congratulated them on that, as it was a matter of experiment whether the lighting up of big towns would pay, and he would rather leave it to others to try.

The motion was then put and carried.

A vote of thanks to the chairman and directors terminated the proceedings.

COMPANIES' SHARE LIST.

TELEGRAPHS.

COMPANIES.	CLOSING PRICES SEPT. 5.		BUSINESS DONE WEEK ENDING SEPT. 5. Highest.	Lowest.
Anglo American	47½,	48	—	—
Do. Preferred	79½,	80	80½	79⅝
Do. Deferred	17,	17½	17½	—
Brazil Submarine	11⅜,	11⅞	11¾	11⅝
Cuba	10½,	11	10⅝	—
Do. Preference	17,	18	—	—
Direct Spanish	5,	5½	—	—
Do. Preference	15½,	16½	16¼	—
Direct United States Cable	12¾,	13¼	13 1-16	12⅞
Eastern Telegraph	10 11-16,	10 13-16	10 13-16	10⅝
Do. 6 per Cent. Preference	13¼,	12¾	12¾	12½
Do. 5 per Cent. Debentures, 1899	103,	107	—	—
Eastern Extension	11¼,	11¾	11 7-16	11 5-16
German Union	9¾,	10½	—	—
Globe Telegraph and Trust Company	7 7-16,	7 9-16	7 9-16	7 5-16
Do. Preference	12¾,	13	12 15-16	12 13-16
Great Northern	12½,	13	12 15-16	12 13-16
Indo-European	30,	32	30½	—
Mediterranean Extension	1½,	2	—	—
Do. Preference	2,	4	—	—
Reuter's	8¾,	9¼	8 13-16	—
Submarine	220,	230	222	—
West India and Panama	⅝,	⅞	—	—
Do. 1st Preference	6½,	6¾	6¾	—
Western Brazilian	5 13-16,	5 15-16	—	—
West. Union 7 per Cent. 1st Mortgage	122,	124	—	—
Do. 6 per Cent. Sterling Bonds	100,	103	—	—

TELEPHONES.

Consol. Telephone and Maintenance	5-16,	7-16	⅜	5-16
Oriental	5-16,	7-16	⅜	—
United Telephone	7¾,	8	8	7½

ELECTRIC LIGHT.

Anglo-American Brush Lgt. (£7 paid)	2½,	3	2¾	2 13-16
Do. (fully paid)	6,	6½	6	—
Hammond Light	1,	1¼	1⅛	1
Eastern Electric (£4 paid)	—,	—	—	—
Swan	1¾,	2	1⅝	—
Maxim-Weston	1-16	3-16	—	—

MISCELLANEOUS.

Telegraph Construction	33½,	33¾	34	33½
India Rubber, Gutta Percha, and Telegraph Works	—,	—	29⅝	28⅝

TRAFFIC RECEIPTS FOR AUGUST, 1883.

COMPANIES.	Aug., 1883.	Aug., 1882.	Increse.	Decre.
Anglo-American Telegraph Company	—	—	—	—
Brazilian Submarine Company	—	—	—	—
Cuba Submarine Company	2,275	2,595	—	320
Direct Spanish Telegraph Company	1,514	1,790	—	276
Direct United States Cable Company	—	—	—	—
Eastern Telegraph Company	—	—	—	—
Eastern Extension Telegraph Company	38,126	32,025	6,101	—
Great Northern Telegraph Company	22,960	—	—	—
Submarine Telegraph Company	—	—	—	—
West Coast of America Telegraph Company	—	—	—	—
Western and Brazilian Telegraph Company	—	—	—	—

NUMBERS OF "THE ELECTRICIAN" OUT OF PRINT.—The following numbers of *The Electrician* are out of print, and cannot be supplied at the office, viz.:—Vol. 1, Nos. 3, 9, 19; Vol. 7, Nos. 8, 10, 12 to 18, 20, 21, 24 to 26; Vol. 8, 1, 3, 6 to 12, 15 to 26; Vol. 9, Nos. 2, 4, 24, 25; Vol. 10, No. 13.

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NOTES.

Cable Interrupted.—The cable between Chorillos and Mollendo is interrupted.

The Portrush Electric Tramway.—This tramway was to have been opened by the Lord Lieutenant of Ireland yesterday (Friday).

City and Guilds Institute.—The next session at the Technical College, Finsbury, begins on October 4, and the next technological examinations will be held on May 28.

Cable Broken.—The telegraph cable between Batavia and Telok Betong was broken (telegrams to the daily papers say "destroyed") by the recent volcanic disturbances in Java.

A Workmen's Society.—A society of working electricians has been formed at Paris under the title "Chambre Syndicale des Ouvriers Electriciens." Its office is at 2, Rue Volta.

Royal College of Science, Dublin.—The next session at this college begins on the 1st October. Experimental physics (theoretical and practical) are taught by Professor Barrett.

Brazilian Submarine Telegraph Company.—The traffic receipts of this company for the weeks ended August 24, 31, and September 7 were £3,064, £3,099, and £2,666 respectively.

Information Wanted.—A correspondent wishes to obtain information as to an electro-therapeutic bath, of American invention, and which is said to have been recently introduced into this country.

New Books.—Amongst the new books which Messrs. Cassell and Co. are about to publish, we notice "Electric Lighting and Transmission of Power," by Professor W. E. Ayrton, and "Fluid Motors," by Professor Perry.

The Volcanic Eruptions in Java.—We notice that the Eastern Extension, Australian, and China Telegraph Company has forwarded £250 towards relieving the necessities of the sufferers by the late volcanic disturbances in Java.

The Electro-magnet and Ophthalmic Surgery.—Mr. Simeon Snell, the author of a recently published work on this subject, gives the honour of the introduction of the magnet into ophthalmic surgery to Fabricius Hildanus in 1646.

Overhead Wires.—Bethnal Green Vestry are of opinion that legislation which will give vestries the control of wires crossing public streets is necessary, and have instructed their parliamentary committee to give their attention to the matter.

Galvanic and Animal Electricity. — Professor McKendrick, professor of physiology in Glasgow University, is announced to give a lecture on this subject at Southport on the 24th inst., on the occasion of the British Association meeting.

The Electric Light at Eastbourne.—It is stated that the Eastbourne Local Board have decided to obtain the services of an expert to test the light supplied by the local Brush company, on the ground that the contract is not faithfully performed.

The Western and Brazilian Telegraph Company.—The traffic receipts of this company for the week ending 7th September, 1883, were £1,936, after deducting the fifth of the gross receipts payable to the London Platino-Brazilian Telegraph Company.

The Canton Riots.—During the riots which took place at Canton on Monday last, the Chinese mob cut the telegraph wires. John Chinaman has never exhibited much liking for the telegraph, and, indeed, has until recently strenuously resisted its extension in the celestial empire.

Eastern Telegraph Company.—Mr. John Pender, M.P., chairman of the Eastern Telegraph Company, accompanied by Sir James Anderson, the managing director, has started for the Mediterranean and the Levant on a tour of inspection of the various telegraph stations belonging to the company in those waters.

Earthquakes.—Since the issue of our last number, the following earthquakes have been reported:—At Casamicciola, Italy, on Sunday and Monday, September 9 and 10. The latest mail news from the west coast of Africa reports earthquake shocks at Salt Pond and District, about fifteen miles from Cape Coast.

Telegraph Materials Wanted.—The Bombay, Baroda, and Central India Railway Company are inviting tenders for the supply of telegraph materials. Tenders are to be sent in by noon on the 19th inst., on forms which can be obtained on application to Mr. Francis Mathew, Consulting Engineer, 45, Finsbury-circus, E.C., by payment of 2s. 6d.

University College, Nottingham.—Workshops and laboratories have now been established in connection with this college, in which a complete course of electrical and mechanical engineering will be given, commencing in October next. The University School, which is connected with the City and Guilds Institute, is under the able supervision of Professor Garnett.

Domestic Electric Lighting.—We understand that Mr. Edward Burke, of Gortmore House, Co. Dublin, has decided to adopt the electric light in his residence. The work has been entrusted to Messrs. Woodhouse and Rawson, of Queen Victoria-street, E.C. It is intended to manufacture gas on the premises, and utilise it to drive a gas engine, which will supply the requisite motive power for the dynamo machines.

The Library Association.—At the *conversazione* given to the members of the Library Association of the United Kingdom meeting at Liverpool, the large book rooms of the Free Library were lighted by fifty high resistance Swan lamps, the current being supplied by storage batteries. The work was carried out by the Liverpool Electric Supply Company, under the superintendence of Messrs. Holmes and Vaudry.

Anderson's College, Glasgow.—We have received a syllabus of the popular evening lectures, to be delivered at this college during the session 1883-4. Prof. James Blyth, F.R.S.E., will lecture on electricity and magnetism on Tuesday evenings. A gas engine and dynamo have been provided to aid in illustrating experiments. Chemistry will be dealt with by Prof. W. Dittmar, F.R.S., on Friday evenings. The fee for each course of 25 lectures is half-a-crown, and this includes the use of the library. Further particulars can be had of Mr. Robert Goodwin, the secretary.

One Way of Looking at it.—In "Practical Electrical Units," by James Swinburne, recently published, the author says:—"Force is generally looked upon as what tends to move matter, and the term 'electromotive force' seems, therefore, a misnomer at first sight. Science does not know what electricity is, but it is supposed to be a kind of motion of molecules or of ether, very closely related to heat and light. Science knows little about molecules or ether, and does not even know if there are such things, but thinks the next thing to understanding anything is naming it."

How to Demagnetise Watches.—M. Deprez gives the

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following as an unfailing method of demagnetising watches which have become magnetised by proximity to dynamo machines, or in any other way:—Place the watch in a powerful magnetic field and impart a rotary motion to it, then gradually withdraw it from the action of this field. By giving the watch a helicoidal motion and gradually withdrawing it, it will become wholly demagnetised. M. Deprez says he has frequently tried this method, and always with success. It may be remembered that Mr. Maxim constructed a small apparatus on this principle, which was, we think, exhibited at the Paris Exhibition.

Another Electric Launch.—On Monday Messrs. Gilbert, Bogle, and Co., of Glasgow, tried one of their electric launches on the Clyde, at Kilcreggan. The current was supplied by one of Clark's patent batteries. The trip is said to have been successful, and as a result the firm are to construct another launch for a Major Macliver, who intends to try a sea trip in it. *The Times* states that Clark's patent dispenses with dynamo machines and accumulators. Naturally, if the current is derived from a primary battery, accumulators would be dispensed with; but how the inventor turns his screw without a dynamo, or more correctly, an electric motor, we do not know. Perhaps *The Times* will explain.

The Gaulard and Gibbs System.—Some time since it was stated that several stations on the Metropolitan line were to be lighted by electric lamps, the current being distributed by the system of secondary generators patented by Messrs. Gaulard and Gibbs. We are informed that this experiment will shortly be carried out. The stations to be lighted are Aldgate, King's Cross, Gower-street, Edgware-road, and Notting Hill Gate. The secondary generators have been made by Messrs. Woodhouse and Rawson, of Queen Victoria-street, E.C., and are just finished. They are wound with a special cable made by this firm. The wiring of the tunnels between the above-named stations is being carried out by Henley's Telegraph Works Company.

Electric Induction.—In a recent note to the Academy of Sciences, Paris, "On the Application of the Amperian Method to the Study of the Elementary Law of Electric Induction by Variation of Current," M. Quet says:—"The apparatus to be used is composed of a series of equal solenoids threaded on a circular support, on which they are arranged at regular intervals. The same quantity of current is caused to traverse the conductors, and we observe whether external induction effects are produced when the quantity is varied. If there is appreciable induction, Weber's law would not be sufficient for this class of experiment; if not, the law would hold good. It remains to be seen whether other laws would not lead to the same result. Let us admit, for a moment, that the experiment is favourable, and let us then consider the equations of equilibrium which Ampère's method gives us. We find that but three laws can satisfy these conditions, that two of these must be rejected as being contrary to other observations, and that we are left with Weber's law.

Leeds.—It is reported that after all the trouble taken in preparing plans and specifications for lighting the new municipal offices, Town Hall, &c., at Leeds, by the electric light, the matter has dropped through. A Leeds paper explains it by stating that a certain section of the committee appointed to consider the tenders sent in insisted upon accepting one that was so low that the practical men on the committee declared it would be impossible for the company tendering to carry out the work at the price. The economists, however, being in the majority, carried the day, and accepted the tender. Subsequently it was ascertained that the company was "in a transition state," which means, we suppose, that it was hastening rapidly to the bourn of speculative limited liability companies, viz., liquidation; and accordingly nothing could be done so far as that tender was concerned. Since that time the committee do not appear to have taken the matter up again, the practical men being in the minority cannot get a hearing, and the unpractical men know nothing about the subject, but want to be, as they think, economical. The probable result will be the abandonment of the scheme.

Telegraph Poles Wanted.—The Postmaster-General is inviting tenders for the supply of 6,945 red fir telegraph poles to be delivered in London; 21,821 to be delivered either at Northumberland Dock (River Tyne) or at West Hartlepool; and 3,750 to be delivered at Dublin. The poles to be felled between 1st November, 1883, and 28th February, 1884, and to be delivered during the following summer. Tenders are also invited for creosoting the above-mentioned poles with 8lb. or 10lb. of creosote to the cubic foot, as may be decided. Tenders may be submitted either for (A) supply of the poles only, (B) both supplying and creosoting, or (C) creosoting only; but if B be tendered for tenders for A and C are also requested. The poles to be delivered at the port at which the creosoting is to be performed. Any person who has not previously supplied the Postmaster-General with poles must submit thin butt sections from not less than three different poles to show the quality of timber offered. Forms of tender, containing all particulars, may be obtained on application, either personally or by letter, to Mr. W. H. Winter, controller of stores, Telegraph-street, Moorgate-street, London. Tenders are to be delivered by noon on the 22nd October.

Waiting for the Electric Light.—A letter, signed "South Kensington," appeared in *The Times* of the 11th instant, in which the writer says:—"I have recently built a house for myself and another adjoining for a friend, throughout both of which I have introduced electric wires. A number of other houses of superior character have been erected close to these, similarly prepared for electricity, and I know of a dozen or two other houses in the immediate neighbourhood the tenants of which are anxious for the electric light. While vestries and companies are disputing as to conditions we are condemned to compulsory darkness, without advantage to the public that I can see, and certainly with loss to the shareholders. I cannot quite understand why, if cities, great and small, in the 'cute United States are without difficulty supplied with electric light, London should still remain in outer darkness, and I cannot but think that we are suffering from an excess of caution which will neither be enlightened itself nor suffer others to be so. There are companies enough eager to supply electric light, and there are thousands anxious to consume it; cannot something be done expeditiously to satisfy both? I am not a shareholder in any electric light company, but merely express the impatience of many desirous of making use of electric light who cannot procure a spark of it in South Kensington."

The International Society of Electricians.—We have received a copy of the rules of this society, which has been recently formed in Paris. It will be composed of three classes of members, two of which will pay subscriptions, whilst the other class will consist of honorary members. An annual meeting will take place in March or April, and ordinary meetings will be held the first Wednesday in every month, at 8:30 p.m., from the 1st October to the 1st July. A bulletin will be issued to members, which will contain reports of these meetings, and the labours of the society. The names of those electricians who took part in the initia-

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tion of this society form a long list, and are sufficient guarantee for the success of the project. Amongst them we notice MM. Allard, D'Arsonval, Aylmer, Berger, Breguet, Cochery, Dumas, Fontaine, Garnier, Hospitalier, Jablochkoff, Joubert, Lemonnier, Lesseps, Marié Davy, Menier, Mercadier, De Meritens, Abbé Moigno, Du Moncel, Planté, Tissandier, Tommasi, Trouvé, and many more well-known electricians, electrical engineers, telegraph engineers, scientific instrument makers, chemists, and others. The president of this committee is M. Georges Berger, with whom many of our readers are doubtless well acquainted, and the temporary office of the society is at the Ministry of Posts and Telegraphs, 99, Rue de Grenelle, Paris. We shall hope to see the new society prosper.

Cromwell Fleetwood Varley.—With reference to our obituary notice of Mr. C. F. Varley, Mr. J. Brailsford Bright writes: "While bestowing all honour due to the illustrious dead it is just to avoid even indirectly denying any of that which belongs to the living. The laying of the first Atlantic cable was successfully completed on the 5th August, 1858. The engineer in charge was my father, Sir Charles (then Mr.) Bright, who received the honour of knighthood chiefly for this, one of the most arduous engineering tasks of modern times. He was assisted by Mr. Canning (since Sir Samuel), Mr. Henry Clifford, Mr. Woodhouse, and Mr. Everett. The chief electrician was Mr. Whitehouse, and the manager the well-known American, Mr. Cyrus Field. This cable subsequently failed through defects in the manufacture—a matter over which those in charge had no control. In the *Illustrated London News* of the 4th September, 1858, and other contemporary journals, full descriptions of this earliest Atlantic cable may be found. As telegraphic engineering developed itself, particularly in the departments of paying-out machines and of insulation, the difficulties of laying and maintaining subsequent cables have greatly diminished. In these improvements the late Mr. Cromwell Varley took a considerable share, I believe. The notices of him which have as yet been published certainly err by no means on the side of too great completeness or too great praise of his varied and indefatigable researches, and of the useful part which he has played in electrical science."

Electricity and Vegetation.—A correspondent sends us the following cuttings from the *Family Herald*, of 1845 (April 26th):—"Perpetual Summer.—Some time since Dr. Forster, of Findrassie, read in the *Gardeners' Gazette*, the account of an experiment which mainly consisted in causing a constant flow or supply of electricity (to be afforded by a common electrical machine) to proceed from a summer house, and which was diffused by a wire through a portion of the surrounding ground. The effect was as reported that vegetation did not cease in the winter on the spot under the influence of this wonderful power, and that what snow fell during the continuance of the experiment never remained as it did on the rest of the garden ground. This impressed Dr. Forster very much, and he has at length instituted a course of experiments. . . . There is a constant stream of electricity going round the earth from east to west, which may be collected by wires placed due north and south, and these wires being placed a few feet above the plant, and a few inches below ground, and communicating at the ends, maintain a constant current of electricity through the soil. The growth of barley was materially promoted, &c., &c. The cost per acre of the electrical apparatus is £1, which will last for 20 years." May 10th, 1845:—"The electrical experiments of D. Forster are to be carefully repeated in the garden of the London Horticultural Society during the season. It is to be hoped that the result of this test and numerous others making by individuals elsewhere will prove the possibility of universally applying this all-pervading power to gardening and farming."

Steamship Lighting.—Quick Work.—The steamer "Gabo," recently built by Messrs. John Keys and Sons, of Kirkcaldy, and which was lighted up by incandescent lamps, arrived in the Thames a few days ago. As her installation, which had been fitted up in Scotland, was found to work unsatisfactorily, the owners commissioned Messrs. Woodhouse and Rawson, of Queen Victoria-street, E.C., to overhaul it and make the requisite alterations and improvements. The work had to be carried out expeditiously in order to enable the ship to sail to time. How quickly it was done may be gathered from the fact that Messrs. Woodhouse and Rawson only received the new dynamo, which it was found necessary to use, at 7:30 p.m. on the evening before the ship left the docks, and that at 2:30 a.m. the installation was running satisfactorily, enabling the ship to sail at 3:30 a.m. The alterations carried out were the substitution of the new dynamo (a Gülcher) for the one previously used, the insertion of fusible plugs in the circuits (none having been provided originally), the changing of the lamps in the saloon from 10 candle-power Woodhouse and Rawson incandescents to 20 candle-power ditto, and altering the speed of the dynamo, it having previously been running much too fast. The "Gabo's" installation consists now, therefore, of one No. 3 Gülcher dynamo, supplying current to 80 Woodhouse and Rawson 10 candle-power incandescent lamps, and twenty 20 candle-power ditto, both requiring an E.M.F. of 48 volts, and two Gülcher arc lights, the advantage of the Gülcher system being that both arc and incandescent lamps can be run on the same circuit.

Electricity and Photography.—The *Photographic Times*, of New York, gives a description of the photographic studio of Mr. Kurtz, of that city. Photographs are taken here by the aid of the light from several Hochhausen arc lamps, pyramidically arranged, whilst another larger lamp is placed opposite to them. The lamps are suspended on movable beams and cross beams in such a manner that they can be moved or propelled individually or collectively in any direction. Each lamp is surrounded by an opal globe, and screened with a violet coloured glass. The camera, posing chair, head rest, and background, with side screens, are placed on a turntable, or platform, which moves on a central pivot, and is worked by the operator. The subject being posed and properly lighted, the focus fixed, and everything else arranged, the shutter is opened and the plate exposed to the action of the light. But that does not end the matter by any means. During the exposure the camera and subject are moved simultaneously at an equal rate, according to the option of the operator, in such a manner that the light travels transversely across the subject, thus neutralising distinct and sharp shadows, blending them with the higher lights into the most delicate modulations. "The effects obtained," says our contemporary, "are marvellous. The lights are fed by a dynamo driven by a 6 horse-power engine. In the basement of the premises connected with the main establishment, there is a branch for the photographing of mechanical and other inanimate objects; for the reproduction of maps, prints, drawings, &c., silver printing, and the making of process plates, all being done by the electric light. Here was recently accomplished the photographing of the electric spark of the telephone in the $\frac{1}{24000}$ part of a second."

The Electrical Transmission of Energy.—We take

the following from the Paris correspondence of *The Times*: "M. Bertroud, the secretary of the Academy of Sciences, read at yesterday's meeting (Monday, September 10) a letter which he had received from Colonel Boulanger, the president of a special commission appointed by the municipality of Grenoble to observe the experiment made by the well-known M. Marcel Deprez for the utilisation of a waterfall near Grenoble in the transmission of force by electricity. Notwithstanding the rather interested and theoretical objections made against his invention after the trial of it at the Northern Railway station, of which you have already spoken, M. Marcel Deprez has persevered in his experiments, and the result, the Academy of Sciences has been informed, justifies his perseverance. A seven horse-power has been obtained at Grenoble, representing 62 per cent. of the initial force taken at the waterfall. This force is moving in the town of Grenoble several printing and other machines. The enthusiasm of the inhabitants seems to have been very great. The *Temps* of this evening says that the town has been illuminated, that banquets are to be given to the distinguished electrician, and that the trial seems to have been an unquestionable success." The *Daily News* also says:—"The *Temps* has the following paragraph on a recent electric experiment:—'M. Bertroud, perpetual secretary, announced to the Academy of Sciences the complete victory of M. Marcel Deprez's invention for transporting electrical force to great distances. Theoretical objections were raised on the occasion of the recent experiments at the Northern Railway station. Certain improvements in the mechanism have since been made, and now Colonel Boulanger, of the Engineers, at the head of a Scientific Government Committee, certifies that a waterfall 14 kilometres from Grenoble was by M. Deprez's apparatus enabled to work to the extent of 7 horse-power a sand mill, a printing press, and other machinery at Grenoble.'" The *Standard* correspondent telegraphing from Paris on Wednesday night, says:—"At the distance of fourteen kilometres (that is to say eight miles and three-quarters English) through a wire only two millimetres thick, and utilising a mountain stream at Vizille as a motive power to work a dynamo machine of his own invention, M. Deprez was last night (Tuesday) able to light one hundred and ten Edison lamps in the Town Hall at Grenoble. Large crowds were present, and were greatly impressed." This information, though interesting, is not of much use, unless we know what horse-power was used at Vizille to drive the generator.

Sleeping with the Head Northwards.—M. G. de Rocquigny writes as follows to M. l'Abbé Moigno, editor of *Les Mondes*, on this subject (see *The Electrician*, September 1, p. 364):—"M. C. Vignier wrote as follows in the *Révue Philosophique* for 1882, No. 7, July, p. 31.: 'Is there, then, an agency capable of exercising a continuous action on the apparata of the nerves (*canaux*), varying with the positions of the head? To my mind this agency exists, and is none other than terrestrial magnetism. That an all-pervading force should be without any action on our organism when we see it influenced by the least variation of light and heat is surprising enough already. But it is beyond dispute that galvanic currents not only exercise a powerful effect on our nervous system, but that electro-magnets themselves produce well marked effects in certain nervous affections. The experiments undertaken at Salpetrière by M. Charcot leave no room for doubt on this point; and there must be some foundation for the practice adopted by the Swedish peasants, who cause themselves to be buried for several hours so as to lay north and south in order to cure neuralgia.' To this the author adds the note:—'I have this fact from M. Nordstrom, Swedish Consul at Alger. It is, moreover, sufficiently proved by physiological experiments that a very close relation exists between the nervous system and electricity, of which magnetism is but one form.' In another note the author quotes the following experiment, carried out by M. Ziégler, of which M. Vogt was a witness:—'M. Ziégler takes a lens of soft iron; he exposes it in a place where it will receive the lines of terrestrial magnetism and redirect them on to the organ to be studied. By thus projecting the magnetic lines concentrated in this manner on the heart of a rabbit, the rhythm of the heart is changed; if the lines are concentrated on the intestine violent peristaltic movements (*péristaltiques*) are caused (*Journal Officiel*, May 18, 1881). The preceding facts will, perhaps, appear to you, Monsieur l'Abbé, to add some degree of probability to the theory put forward by *The Electrician* of London.'"

The Electric Tramcar in Paris.—The Paris correspondent of the *Standard*, telegraphing on Thursday night (September 6) says:—"The electric tramcar trial, of which I gave notice in my yesterday's letter (see note in last week's *Electrician*), was successfully accomplished to-day by the French Electrical Power Storage Company. At three o'clock the vehicle (an ordinary three-horse tramcar) left the Place de la Nation in the far east, and after traversing the capital through the important thoroughfares named in my last letter, reached the starting point soon after six o'clock. A distance of thirty English miles was thus made in about three hours. The mute wonderment with which the soundless progress of the apparently animated car through the crowded streets was witnessed by the public may be imagined. There was not the slightest accident, and not a single horse shied throughout the entire route. Whenever there was an impediment the driver, directed by M. Philippart, the manager of the company, who was ever on the alert, had no difficulty in bringing the vehicle to a standstill at a second's notice. The ease with which the car was turned off one set of tram lines and got on to another across several yards of unmetalled ground was likewise admirable. The locomotion is effected by means of Faure accumulators, weighing some fifty hundredweight, which are fixed under the tramway seats, and connected with a Siemens machine placed under the floor. The machine, which makes twelve hundred revolutions a minute, sets in movement, by means of a pulley, an axle, to which are connected the chains which give impulse to the wheels. These wheels revolve sixty times to twelve thousand revolutions of the machine. The speed of the electric tramcar is nine and a third miles an hour on level ground, and five and a half miles on an ascent. The present tram lines are not well adapted for the new locomotion. On the newer lines the movement was sufficiently smooth, but on those that have been laid for some time there was a marked difference, and the actual working force was considerably lower than the indicated horse-power. To-day's experiment, however—the first ever made over a long distance—fully proves the practicability of electric tramcars, and it may safely be predicted that before long they will take possession of the tram routes of the French capital. The estimated cost is one-half that of horse trams. The company who made the trip to-day consisted of engineers and journalists. M. Ferdinand de Lesseps was among them. On Sunday next a trip will be made from Vincennes to Versailles." Without in any way wishing to discount the "safe prediction" of the *Standard's* correspondent, we would advise our readers to wait until they have the bill before them, prior to believing that traction by means

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of accumulators costs less by one-half than horse traction. Glad as we shall be to see electrical supersede animal traction, we think that the question of cost will need trials on a large scale before it is accurately answered. And estimates are so lamentably liable to grow by leaps and bounds during their passage from the embryo state of estimate to that of a full grown account rendered.

A Plea for Pure Science.—Dr. H. A. Rowland, of Baltimore, delivered an eloquent address as Vice-President of the Physics Section at the meeting of the American Association for the Advancement of Science, held at Minneapolis, on the 15th August. Dr. Rowland pleads with his countrymen in the cause of pure science, in almost identical terms with those employed by Dr. Gore in his recently published work, "The Scientific Basis of National Progress" (*vide Electrician* for September 1, p. 372). We quote a few paragraphs from his address. In his opening sentences he says:—"American science is a thing of the future, and not of the present or past; and the proper course for one in my position is to consider what must be done to create a science of physics in this country, rather than to call telegraphs, electric lights, and such conveniences by the name of science. I do not wish to underrate the value of all these things; the progress of the world depends on them, and he is to be honoured who cultivates them successfully. So also the cook who invents a new and palatable dish for the table benefits the world to a certain degree, yet we do not dignify him by the name of a chemist. And yet it is not an uncommon thing, especially in American newspapers, to have the applications of science confounded with pure science; and some obscure American who steals the ideas of some great mind of the past, and enriches himself by the application of the same to domestic uses, is often lauded above the great originator of the idea, who might have worked out hundreds of such applications had his mind possessed the necessary element of vulgarity. I have often been asked which was the more important to the world, pure or applied science. To have the applications of a science the science itself must exist. . . . We are tired of seeing our professors degrading their chairs by the pursuit of applied science instead of pure science, or sitting inactive while the whole world is open to investigation, lingering by the wayside while the problem of the universe remains unsolved.. For generations there have been some few students of science who have esteemed the study of nature the most noble of pursuits. Some have been wealthy, and some poor; but they have all had one thing in common. The love of nature and its laws. To these few men the world owes all the progress due to applied science, and yet very few ever received any payment in this world for their labours." Dr. Rowland then reviews the causes that have led to the neglect of pure science in America, prominent amongst which have been the fact that "in a new country the necessities of life must be attended to first; we must earn our bread." He concludes as follows: "The whole universe is before us to study. The greatest labour of the greatest minds has only given us a few pearls; and yet the limitless ocean, with its hidden depths filled with diamonds and precious stones, is before us. The problem of the universe is yet unsolved, and the mystery involved in one single atom yet eludes us. The field of research only opens wider and wider as we advance, and our minds are lost in wonder and astonishment at the grandeur and beauty unfolded before us. Shall we help in this grand work, or not? Shall our country do its share, or shall it still live in the almshouse of the world?"

Telephone Wires and Private Property.—On Thursday, September 6, in the city of London Court, an important case, involving the relative rights of property owners and telephone companies was disposed of. We take the following account of the proceedings from the daily press:—"The plaintiff was Mr. W. H. German, an independent gentleman, residing at the Hove, Brighton, and owner of certain building land at Bow, and the defendants were the United Telephone Company, of 36, Coleman-street, City, who were sued for £50 damages for erecting posts and wires on the land in question without leave. Pending the hearing Mr. George Kebbell, solicitor, Seething-lane, applied some weeks ago on behalf of the plaintiff for an injunction restraining the company from carrying out any further trespass. It was then held by Mr. Commissioner Kerr that according to English law an owner was entitled to the enjoyment of everything between his property and the heavens, and he asked why the plaintiff did not cut the wires (vide *Electrician* for Aug. 18, p. 315)? Mr. Kebbell replied that he purposely refrained from advising such a course lest injury might accrue to life and limb, whereupon the learned commissioner remarked that even in that event the plaintiff would not be liable to a charge of manslaughter, and considering the multiplicity of telephone wires recently erected it was desirable that the public should know that such was the fact. On the case being now called on, it was taken by Mr. T. Speechly, the registrar of the court.—Mr. Allen, barrister, who appeared for the company, stated that there need not be any further contention between the parties, as the posts and wires had been removed.—Mr. Kebbell: No doubt that is the fact; but I submit that all the circumstances of the case entitle the plaintiff to adequate damages, because the company have only lately agreed to make the amends which they ought to have done some months ago. Besides, when the plaintiff attempted to remove the posts, force was used to prevent him.—The Registrar: Tell me of any actual damage which has been sustained and I will deal with it.—Mr. Kebbell: Surely a public company cannot commit a wrong of this sort against a private person, and maintain it till the last moment, without the law compelling them to give proper redress.—The Register: You have not claimed for special damage.—Mr. Kebbell: Well, my client had an opportunity of selling the land and he could not carry out the bargain so long as the posts were up. That was certainly a hardship.—The Registrar: But was he prevented from effecting a sale?—Mr. Kebbell: I cannot go so far as that. I have offered to take 20 guineas as damages. They have already offered £10.—Mr. Allen: I think the company have acted in a very reasonable way. Only nominal damages can be recovered.—The Registrar: I do not think the parties have been prejudiced at all.—Mr. Kebbell: The learned commissioner said if I proved my case he would give me £50 damages per month.—The Registrar: Are the company still prepared to give £10?—Mr. Allen: I do not know that.—The Registrar: Having made the offer are you not bound by it? You have used this gentleman's land to a certain extent. How long were the wires up?—Mr. Kebbell: Since February until within the last 48 hours.—Mr. Allen: We do not deny that we have committed a technical trespass, but that is all. Ultimately the registrar fixed the damages at 40s. with costs on the higher scale.—Mr. Kebbell: How about the costs of the application for an injunction?—The Registrar: I will deal with them on taxation.—Mr. Kebbell: The worst feature of the case is that the company may erect the posts again to-morrow. It is not creditable to them to offer £10 and then withdraw it.—The Registrar: On that I make no comment whatever."

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CURRENT ENERGY.—VIII.

BY OLIVER HEAVISIDE.

(CONTINUED FROM PAGE 344.)

We had occasion in Article VII. to consider the distribution of steady current in a conducting body of any conductivity, uniform or variable, and with or without identity of properties as regards the electric current in different directions, such system of current being supposed to be kept up by E.M.F. arising purely from difference of potential, there being supposed to be no internal intrinsic E.M.F.'s. This is, however, an ideal state of things. For, in a perfectly homogeneous and non-crystalline conductor there are intrinsic E.M.F.'s unless every part of it be at one temperature. And, whenever there is change of material or of structure there is usually intrinsic E.M.F., even without change of temperature at the place. Also, in a naturally crystalline, or in an originally isotropic material when strained, the intrinsic E.M.F.'s arising from difference of temperature are altered so that the thermo-electric qualities vary in different directions. In general, when an electric current passes from one material to another, or in one material from a hot to a cold place, it produces, besides the ordinary "frictional" generation of heat according to Joule's law, which, varying in amount as the square of the current, is irreversible, or always positive, thermal effects which are reversible with the current, being a heating or a cooling, according to its direction. To the consideration of the theory of these reversible effects we now proceed.

If a conductor forming part of a galvanic circuit, or of a circuit containing any constant source of electrical energy outside the conductor under observation, is wholly of one homogeneous metal, and is all at the same temperature, the heat which is the result of the current is generated uniformly per unit of resistance, the amount being RC^2 per second in a portion of resistance R, with the steady current C. But if the conductor is made up of a number of different metals, still all at one temperature, there will be, besides the above heating, a heating effect at some junctions and a cooling at others, their sum balancing on the whole, so that the whole heat is still in accordance with Joule's law. And when the current is reversed, at any junction where there was previously a heating there will now be a cooling, and *vice versâ*. This is the Peltier reversible thermal effect of the current.

To particularise, when an iron wire is inserted between two copper wires, and a current is passed through them, there is a cooling at the junction where the current goes from copper to iron, and a heating where it goes from iron to copper, whilst away from the junctions the heating is as the square of the current. The amounts of these heating and cooling effects are found to vary in simple proportion to the strength of the current (their reversibility shows that they must vary as some odd function of the current—first, third, &c., powers or combinations). Hence, in the resistance R containing a junction the heat per second is not RC^2 but $PC + RC^2$, where P is a quantity independent of C. What it does depend on will be seen later. P is positive at the iron-copper junction, and negative at the copper-iron junction (the order of the linked metals showing that of the current), or the extra heat is PC at the iron-copper and the deficiency PC at the copper-iron junction, if we reckon P always positive. We have thus a transference of an amount of heat PC from the copper-iron to the iron-copper junction, when both are at the same temperature, taking place, not by heat conduction, but through the medium of the energy of the electric current we pass through the wire.

Since RC^2t represents an amount of energy, and also PCt, both being heats generated in time t, the quantity P is clearly an E.M.F. In fact, if E is the externally impressed E.M.F., we have $EC = PC + RC^2$. Hence $E - P = RC$, or the actual E.M.F. is $E - P$. Thus, from the Peltier effect we recognise the existence of at least two E.M.F.'s in the circuit besides that of the battery, which do not, at least immediately, appreciably alter the current strength from their being equally strong and oppositely directed in the circuit, and whose localities are the two junctions. In short, there is an E.M.F. P from copper to iron at both junctions. This is the real contact force of copper and iron. All others are counterfeits. To distinguish it from the apparent contact force of copper and iron in air or other medium, often erroneously referred to the metallic contact, we shall call it the Peltier E.M.F.

Any two metals exhibit the Peltier E.M.F., and to a different extent at different temperatures. Its magnitude is obtainable without ambiguity by measurements, when possible, of the reversible heat effect at a junction. If it is a cooling, the E.M.F. acts with the current; if a heating, against it; and the magnitude of P (being, of course, PCt/Ct), is numerically equal to the extra heat produced during the passage of the unit of electricity through the junction, and is found by dividing the extra heat in time t by the integral current in that time. The extra heat may be found by two measurements of the whole heat generated, one with the current from copper to iron, and the second from iron to copper, their difference being twice the Peltier effect.

Now, we could not expect on cutting out the battery to observe any current in a closed circuit of copper and iron if one E.M.F. continued to exactly balance the other, as happens when the junction temperatures are equal. And, in fact, in a circuit of any number of metals whose junctions are all at one temperature no current is to be observed; hence, just as for two metals we have $P_{ab} + P_{ba} = 0$ (the order of the small subscript letters indicating the direction of the E.M.F., thus in P_{ab}, from metal a to metal b), so for three metals we must have $P_{ab} + P_{bc} + P_{ca} = 0$ at one temperature, with similar extensions to any number of metals. This summation law of Peltier E.M.F.'s shows that we may refer all metals to one metal as a standard; hence we may drop the letter when the standard is one of the metals. P_a and P_b being the Peltier E.M.F.'s from a and from b to the standard metal, that from a to b, or P_{ab}, is $P_a - P_b$.

But our battery current heated the iron-copper and cooled the copper-iron junction, destroying the equality of temperature, and on cutting out the battery there is a weak current found in the circuit whose direction is opposed to the original current, viz., from copper to iron at the warmer junction, which ceases quickly on restoration of equality of temperature. It may, however, be maintained indefinitely by mere application of heat to one of the junctions to keep up a difference of temperature, and the current will be always from copper to iron at the warmer junction when the temperature does not depart greatly from the ordinary atmospheric temperature. We now have the thermo-electric current of Seebeck and Cumming. As the current in this case is in the reverse direction to that of the battery current which would cause the same difference of temperature, there must now be a transference of heat in the reverse direction, viz., from the warm to the cold junction; heat must be supplied at the warm junction to prevent it cooling, and heat must be taken away at the cold junction to keep it from getting warmer, quite apart from the frictional heat, and the alteration of temperature by thermal conduction, radiation, &c. P_1 and P_2 being the Peltier E.M.F.'s, now no longer equal, we should have $P_1 - P_2 = RC$ by Ohm's law. Also P_1C of heat absorbed at the hot junction per second, P_2C generated at the cold, and their difference, which equals RC^2, frictionally generated. This is in accordance with Ohm's law and the law of conservation of energy, with the assumption that there are no other E.M.F.'s than the Peltier in the circuit.

So far, we have no knowledge of how P varies with the temperature, except in this respect: that since P is from copper to iron when both the metals are at the same (ordinary) temperature, and the current is from copper to iron at the warmer junction when its temperature is raised, it follows that if P_2 be the E.M.F. at the cold and P_1 at the warm, both from copper to iron, P_1 must have been increased by the heating, for P_2 remains the same, the temperature of the cold junction being unaltered. But this legitimate conclusion is soon found to be utterly erroneous. For if we keep the cold junction constantly at, say, 0°C., and continuously raise the temperature of the other junction, the current in-

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creases up to a maximum (when the hot junction is at about 275°C.), and then decreases to nothing at a higher temperature (about 550°C.), and immediately sets in the reverse way on further heating, viz., from iron to copper at the hot junction.

Now, it has been proved that when a junction is at the temperature 275°C., there is neither absorption nor generation of heat there, *i.e.*, $P_1 = 0$, or the metals, iron and copper, are thermo-electrically neutral at this temperature. Hence, when the hot junction is at this neutral temperature, the current being from copper to iron *there*, and the only known E.M.F. being from copper to iron at the *cold* junction, the current is against the E.M.F. Therefore there must be other E.M.F.'s in the circuit not at the junctions, whose sum is greater than P_2, the Peltier E.M.F. at the cold junction, and opposed to it in direction. Three courses are open: (1). There must be an E.M.F. in copper from cold to hot, with possibly a weaker in the iron, also from cold to hot. (2). Or, E.M.F.'s in the copper and iron from hot to cold, the latter being the greatest. (3). Or, an E.M.F. in iron from hot to cold, and in copper from cold to hot. In all three cases their sum to be greater than P_2, and against it in the circuit.

The existence of E.M.F.'s (with reversible thermal effects) in unequally heated wires was theoretically predicted by Sir W. Thomson, reasoning from the behaviour of iron and copper, and he afterwards verified his prediction experimentally, and determined the directions of the E.M.F.'s. The reasoning itself is of the simplest character, but the results thereof may be put into a form likely to cause some bewilderment. Following the analogy of a material fluid moving in a pipe unequally heated, and giving out or receiving heat in its motion, Sir W. Thomson expressed his results in terms of the convection of heat by vitreous or by resinous electricity. If the E.M.F. in a metal is from cold to hot, the specific heat of electricity in that metal is positive, and it is the vitreous electricity that carries heat with it; whilst, if the E.M.F. is from hot to cold, the specific heat is negative, and the resinous electricity conveys the heat. For, imagine the fluid at rest in the pipe in the first place, the fluid having everywhere the temperature of the pipe at the place where it may be. Set the fluid moving; as the fluid moves from colder to warmer places it receives heat from and, therefore, cools the pipe; this heat it carries with it until it reaches places where the temperature falls, when it gives out the heat and warms the pipe. We have similar heat effects in a wire when the E.M.F. acts from cold to warm, a cooling when the current passes from cold to warm, and a heating when from warm to cold, hence the electric current acts as a real fluid would do. But should the E.M.F. be from hot to cold, the heat convection would be reversed, therefore now it is the resinous electricity that carries heat with it. When I first read Sir W. Thomson's account of his experiments to determine which electricity it was that carried the heat in copper or in iron, I was seized with vertigo, and fell down on the table. Even now, I have a lurking suspicion that there may be after all something intended to be conveyed by the expression "vitreous (or resinous) electricity carries heat with it" that I have failed to grasp. However, except as to the supposititious hidden meaning, all that it is necessary to remember is whether the E.M.F. acts from cold to hot or from hot to cold. The corresponding absorptions and generations of heat when a current passes may be of course easily deduced.

Let σ be the E.M.F. from cold to hot per unit rise of temperature in any metal. Then σ is Sir W. Thomson's specific heat of electricity ("without hypothesis, but by an obvious analogy.") It would be very much better if this important quantity had a less misleading name, but I cannot at present think of a suitable word to convey a connection between an E.M.F. and a rise or fall of temperature. But the whole E.M.F. in a wire due to this cause may be suitably called the Thomson E.M.F., as the reversible heat effect is called the Thomson effect; similarly to Peltier effect and E.M.F. Thus the Thomson E.M.F. in a wire whose terminal temperatures are t_1 and t_2, t_1 being the higher, is simply $\int_{t_2}^{t_1} \sigma \, dt$, acting when it is positive from the low to the high temperature. In a closed circuit of one metal, it vanishes; the terminals, which may now be anywhere, having the same temperature.

Regarding this it was proved by Magnus that there was no current in a closed circuit of one metal, however the temperature varied, and also however the section varied. Though this has been shown later to be not always rigidly true in extreme cases, yet the departures are very small. Assuming its exact truth, it follows that in a circuit of one metal the E.M.F. from one point to another must be the same by either path; and generally, the integral E.M.F. between points at temperatures t_2 and t_1 must be independent of the intermediate temperatures, and therefore must equal $T_1 - T_2$, where T_1 and T_2 are the values at temperatures t_1 and t_2 of a function T of the temperature only (for a single metal), the E.M.F. per unit rise of temperature being therefore dT/dt. Therefore, if T_a and T_b are the values of T for two metals a and b, the complete E.M.F. in a circuit of two metals (which might be called the Seebeck E.M.F.) is

$$E_{ab} = [P_{ab}]_2^1 + [T_a - T_b]_2^1, \quad . \quad . \quad . \quad (1)$$

where the square brackets indicate that the difference of the functions at temperatures t_1 and t_2 must be taken. The T's being reckoned from cold to hot, the Peltier E.M.F. from a to b, and t_1 being the higher temperature, when E_{ab} is positive the current sets in from a to b at the hot junction. In terms of σ we have

$$E_{ab} = [P_{ab}]_2^1 + \int_{t_2}^{t_1} (\sigma_a - \sigma_b) \, dt \quad . \quad . \quad . \quad (2)$$

How P and σ vary with the temperature there is nothing to show so far, except that we know that with copper and iron P falls to zero as the temperature rises from 0° to 275°, whilst, as Sir W. Thomson found, σ is positive in copper and negative in iron, or the E.M.F. is from cold to hot in copper and from hot to cold in iron. This was to the discoverer a most unexpected conclusion, he expecting to find σ either positive in both or negative in both, having a slight bias in favour of the first. Thus, both Thomson E.M.F.'s act the same way in the circuit as if from copper to iron at the hot junction.

The phenomenon of thermo-electric inversion or reversal of direction of the current by raising the temperature of one junction, discovered by Cumming and Seebeck, is not peculiar to iron—though certainly especially noticeable when iron is one of the metals paired—but is an almost general property of any two metals or alloys, with sufficient range of temperature. It is so easily observed in the iron-copper couple that it is scarcely credible that many early observers should have been unable to verify it. An interesting way of observing it is with the telephone. Connect a low resistance telephone with a copper wire, with an iron wire inserted, and make and break connection so rapidly by means of a rheotome that a weak current in the circuit will give a pure musical tone. Warming a junction with the hand will bring on the sound. Bringing it near a hot flame will be sufficient to raise the sound to its maximum, which is when the neutral point is reached. On further heating, the sound falls steadily to a dead silence, and then returns. This is at about low red heat. Still further heating raises the sound steadily up to about twice the loudness at its former maximum, and at the highest temperatures the sound is about stationary. That is to say, on first removal from the source of heat, although the junction is cooling most rapidly, yet the sound is stationary for a moment, or falls only slowly, before the rapid fall sets in and the reverse phenomena occur. This shows that there is a second maximum; and, in fact, with a thin steel wire, there was a decided increase of sound on first removal from the source of heat, showing that the second maximum had been passed, which I could not observe with soft iron. The temperature of the junction at the second maximum could not be much less than the melting point of copper, 1,090°C., for the thin copper wire did partially melt sometimes. On the other hand, if the wires be thick, it is much more difficult to heat them sufficiently. The reason of the second maximum will appear later.

In saying that there is no current in an unequal circuit of one metal, it is of course to be understood that the metal

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is all the same metal—not merely all copper, for instance, but the same copper. Different specimens may give strong thermo-electric currents. Thus, two copper wires of the same gauge and make gave, when one of their junctions was at bright red, a current nearly as strong as that in the copper-iron couple at the first maximum, which indicates an E.M.F. of about ·003 volt, and it was the same with several fresh joints, proving a great difference of quality. It sometimes happens, too, that the sudden insertion of a wire into a flame will bring on a faint sound, without any possibility of heating of junctions. This may be due to a difference of structure in parts of the same wire, either existing originally, or brought on by different parts of the wire having been subjected to different treatment before the experiment, and not having returned to identity.

(TO BE CONTINUED.)

POTENTIAL, CURRENT, AND RESISTANCE.—IV.

BY JOHN T. SPRAGUE.

(CONTINUED FROM PAGE 319.)

41. In Paper II. of this series I showed that electromotive force is properly comparable to the velocity generating power of gravity, which corresponds in hydraulics to the square root of head of water, and also to the square root of potential energy. But in Section 19 I remarked that under another aspect it would be found to represent *potential* energy itself and not its square root. The figures given in Paper III., Sections 37—39, show clearly that E.M.F. is, in fact, directly proportional to the potential energy transformed in a chemical action, and that when we take into account the atomic constitution of matter, E.M.F. can be expressed definitely in terms of energy, the volt being equal in value to the "equivolt" (Section 40), and representing 4,673 foot-pounds, when we make our unit of electric quantity consist of one grain equivalent of chemical action effected at the unit ampere rate of current, which requires 6,338 seconds, this therefore becoming the unit of time.

42. *Potential Regarded as Energy.*—Let us now work out the idea that E, electromotive force or potential, as expressed in volts represents *the potential energy stored upon and to be expended within the unit molecular chain*, the links of this chain corresponding to one grain equivalent of chemical action.

We have here two distinct quantities to deal with; those which are generally confused together under the common name of electricity—two quantities which some express as E and E^2, but which need to be clearly separated if we are to understand the nature of electricity and its actions. These two quantities are—

(1) A *quantity of energy, Q*, which, under the conditions now defined, is equal to 4,673 foot pounds.

(2) A quantity, so called, Q, which is treated in different manners by the different schools of electricity, according to the theories held of the nature of electricity. By the material or fluid schools it is called a "quantity of electricity." It is that which is expressed by the electro-static unit of quantity, or by the coulomb, which corresponds to 3×10^9 of those units.

By the molecular school it is regarded as an action, and is represented by the quantity of matter which is affected by the electrical action, which both schools recognise as the "coulomb equivalent" say ·0000102 of hydrogen. Here it will be represented by 6,338 coulombs, the value corresponding to 1 grain equivalent of chemical action associated under the unit system with the 4,673 foot-pounds of energy.

43. There is no more real mystery about these two quantities in electricity than there is in ordinary mechanics, where also they are constantly present. The mystery which surrounds them in the usual mathematical treatment is entirely due to the artificial electricity which has been invented by the various theorists. We can examine them and their relations by a modification of the hydraulic analogy of Sections 16 and 17, where we considered E.M.F. as related to velocity and current, and as corresponding to the square roots of potential energy and head of water, to which we are now to consider it as directly related.

44. But while in Section 37 (k) velocity or current is stated to be as the square root of head of water, the formulæ for working out hydraulic problems are usually based upon *head of water* simply, and the resistances are reckoned in terms of the "head" necessary to overcome them, which by so much reduces the head effective for generating current.

We cannot adopt this process, because the mechanical and electric analogy is not perfect, for the reasons stated (Sections 21 and 25). The running water, the falling weight, retain in themselves a portion of the energy belonging to the fall, greater in proportion to its rapidity, while in the case of electricity the energy is wholly expended. Most hydraulic formulæ relate really to this residual energy, which has no counterpart in electric problems, and on the other hand it is because the expenditure of energy, *within the circuit*, which is the essential element in the electrical problems, is in some aspects expressible only in terms of the square of the other quantity Q, of Section 42, 2, to which it is connected, that Ohm's formulæ, as relating to both quantities, may be considered in such seemingly inconsistent manners as stated (Sections 19, 45). We can, however, deal with the analogy by considering the unit electrical conditions as comparable with those of a column of water 4,673 feet in height, with a conducting pipe such as allows a unit quantity (4,673 pounds of water) to flow in 6,338 seconds, which is a current of pound ·7373 per second. In this case the quantity and energy are expressed in the same term of the pound as a value corresponding to the unit energy of the ampere current, *i.e.* the joulad, which is ·7373 of the foot-pound.

The same idea will probably be more completely received by some readers in the form of a pound weight suspended by a cord 4,763ft. long, and doing work while it descends in the normal time of 6,338 seconds.

46. It will be well to trace out the relations step by step.

(a) Electromotive force, E, means a quantity, *Q*, of potentential energy (of which the unit =1 volt is 4,673 foot-pounds) charged upon a chain of molecules corresponding to a quantity, Q, which is, for each link of the chain, one grain equivalent of chemical action.

Mechanico-motive force (Section 11) will in like manner be represented by the column of water, or the weight of Section 45.

(*b*) This *potential* energy is, in the electrical case, *wholly* converted into *kinetic* energy, but the *rate of conversion* depends upon the conditions under which it takes place.

(*c*) *Rate of conversion* of energy, *Q*, is proportional to the rate of chemical action, Q; both correspond to the fall of the water or the weight (Section 45).

(*d*) *Current is quantity divided by time;* that is to say, it is rate of conversion or transmission. It is usually considered as the latter only, but it is necessary to extend the idea of the current to energy as well as matter or electricity; therefore

$$\frac{\mathrm{Q}}{\mathrm{T}} = \mathrm{C}, \text{ and } \frac{Q}{\mathrm{T}} = C.$$

(*e*) Unit time is 6,338 seconds, and therefore unit C = $\frac{1}{6338}$ of hydrogen, and unit $C = \frac{4673}{6338} = $ ·7373ft.-lb.

(*f*) We see that in this formula, T, time, replaces R, resistance so called, in the ordinary Ohm's formula; in fact, the statement that current is quantity divided by time, or the converse statement that quantity = C × T, and the statement (*b*) that rate of conversion or transmission depends upon the conditions under which it occurs, are the same thing differently expressed, for time is simply the inverse measure of relative facilities of conversion and transmission; if the facility of transmission is reduced to half, as by halving the area of a conductor, the time of transmission of unit quantity is doubled.

(*g*) *Time of flow* of unit quantity is, therefore, the measure of conducting capacity, and is the real thing represented by the so-called resistance, the R of Ohm's formulæ, which in Section 22 was shown to represent the reciprocal of this capacity. In fact, current is *as conducting capacity*, and it is also inversely as time or as resistance, whichever expression best suits particular requirements.

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(*h*) ***Electric resistance,*** the R of Ohm's formulæ, represents really *the time during which the unit of potential energy becomes kinetic,* and this, under the unit conditions of the grain equivalent, is 6,338 seconds; but this definition is limited to the action of unit E.M.F.

(*i*) The conducting capacity of any circuit is proportional to the E.M.F. acting upon it (Section 24), for this is only another way of stating the fact that current is as the E.M.F., or that the resistance is alike for all currents. In other words, the actual capacity = the unit × E, and it is the reciprocal of this which constitutes the artificial "electric resistance" R, though this is arrived at by methods apparently independent of the variable E.M.F.

(*k*) To make the definition of (*h*) general, we must in like manner take into account the E.M.F. operating, and then we shall find that R corresponds to T × E, time divided by E.M.F. as to the unit energy (*i*), but to T, or time direct, when T is related to current, that is when C + T = Q, or when T = 6,338 ÷ C.

(*l*) The reason of this is evident when we consider that we are dealing with limited quantities Q and *Q*, divided by time T, while Ohm's formula deals not with a general quantity, but only with the quantities related to a single second.

(*m*) Thus, if we double E we double current C, and therefore halve the time T during which the unit quantity Q (to which our consideration is limited) passes. But, by doubling E we have doubled the quantity of energy *Q* connected to the material quantity Q, and therefore we have these conditions :

$$\text{As to matter, } \frac{2\,E}{1\,R} = 2\cdot C, \text{ and Q is } \frac{C}{2} \times \frac{T}{\cdot 5} = 1.$$

$$\text{As to energy } \frac{2\,\mathcal{Q}}{\cdot 5\,T} = 4\cdot \mathcal{C}, \text{ and Q is } \frac{\mathcal{C}}{4} \times \frac{T}{\cdot 5} = 2.$$

These are the conditions of (*a*), those of the unit molecular chain corresponding to Q, upon which are charged quantities of energy corresponding to *Q* × E, agreeing also with the laws of energy as corresponding to $C^2 \times R$, or C × E.

47. Probably a few examples may make the matter more evident.

Action of Q = Current.

$$\frac{1 \text{ volt}}{1 \text{ ohm}} = 1 \text{ ampere} \qquad \frac{1\,E}{1\,R} = 1\,C$$

$$\frac{E, 1\cdot}{R\ \cdot 5} = C\ 2\cdot \qquad \begin{matrix} J \times E \times C \\ J \times C^2 \times R \end{matrix} = \begin{cases} \text{ft. lb.} \\ 1\cdot 479 \end{cases}$$

$$\frac{E, 2\cdot}{R\ \cdot 5} = C\ 4\cdot \qquad J \times 2 \times 4 = 5\cdot 899$$

$$\frac{E, \cdot 5}{R\ 2\cdot} = C\ \cdot 25 \qquad J \times \cdot 5 \times \cdot 25 = \cdot 092165$$

Action of Q = Energy.

$$\frac{\text{Ft. lb. } 4673\cdot}{\text{Seconds } 6338\cdot} = \cdot 7373 \qquad \frac{1\,E}{1\,T} = 1\,\mathcal{C} = J.$$

$$\frac{E\,1 = 4673\cdot}{T = 3169\cdot} = 1\cdot 479 \qquad T = \frac{6338}{C = 2\cdot}$$

$$\frac{E\,2\cdot = 9346}{T = 1584} = 5\cdot 899 \qquad T = \frac{6338}{C = 4\cdot}$$

$$\frac{E\ \cdot 5 = 2336}{T = 25352} = \cdot 092165 \qquad T = \frac{6338}{C = \cdot 25}$$

I will work this last example fully in logarithms.

E ·5	= $\bar{1}\cdot 6989700$	unit time	6338·	=	$3\cdot 8019440$
R 2·	= $0\cdot 3010300$	C =	·25	=	$\bar{1}\cdot 3979400$
C ·25	= $\bar{1}\cdot 3979400$	T =	25352	=	$4\cdot 4040047$
J ·7373	= $\bar{1}\cdot 8676563$	unit *Q*	4673·	=	$3\cdot 6696010$
E ·5	= $\bar{1}\cdot 6989700$	E	·5	=	$\bar{1}\cdot 6989700$
	$\bar{2}\cdot 9645663$	*E*	2336	=	$3\cdot 3685710$
		T	25352	=	$4\cdot 4040047$

Energy expended per second = ·092165 $\bar{2}\cdot 9645663$

Showing the potential energy of the E.M.F. converted into kinetic energy in transmitting current.

THE NEW STANDARD WIRE GAUGE.

The following is the recent Order in Council legalising the new standard wire gauge. It was given at the Court at Osborne House, Isle of Wight, on the 23rd ult.:—

"Whereas by The Weights and Measures Act, 1878, it is (among other things) provided that the Board of Trade shall from time to time cause such new denominations of standards, being either equivalent to or multiples or aliquot parts of the imperial weights and measures ascertained by the said Act, as appear to them to be required in addition to those mentioned in the second schedule to the said Act, to be made and duly verified, and that those new denominations of standards, when approved by Her Majesty in Council, shall be Board of Trade Standards in like manner as if they were mentioned in the said schedule:

"And whereas it has been made to appear to the Board of Trade that the new denominations of standards set forth in the schedule hereto, being equivalent to or multiples or aliquot parts of the imperial measure of an inch ascertained by the said Act, are required, in addition to the denominations of Standards mentioned in the second schedule to the said Act:

"And whereas they have caused the said new denominations of standards to be made and duly verified:

"Now, therefore, Her Majesty, by virtue of the power vested in Her by the said Act, by and with the advice of Her Privy Council, is pleased to approve the several denominations of standards set forth in the schedule hereto as new denominations of standards, and doth direct that the same, on and after the first day of March, 1884, be Board of Trade Standards in like manner as if they were mentioned in the second schedule to The Weights and Measures Act, 1878.

"C. L. PEEL."

SCHEDULE.

Denominations of Standards.

Descriptive Number.	Equivalents in Parts of an Inch.	Descriptive Number.	Equivalents in Parts of an Inch.
No.	Inch.	No.	Inch.
7/0	·500	23	·024
6/0	·464	24	·022
5/0	·432	25	·020
4/0	·400	26	·018
3/0	·372	27	·0164
2/0	·348	28	·0148
0	·324	29	·0136
1	·300	30	·0124
2	·276	31	·0116
3	·252	32	·0108
4	·232	33	·0100
5	·212	34	·0092
6	·192	35	·0084
7	·176	36	·0076
8	·160	37	·0068
9	·144	38	·0060
10	·128	39	·0052
11	·116	40	·0048
12	·104	41	·0044
13	·092	42	·0040
14	·080	43	·0036
15	·072	44	·0032
16	·064	45	·0028
17	·056	46	·0024
18	·048	47	·0020
19	·040	48	·0016
20	·036	49	·0012
21	·032	50	·0010
22	·028		

The ironmasters of Wolverhampton and neighbourhood have expressed great dissatisfaction with this new gauge, and have recommended the trade to ignore it. Their objection is based upon the fact that it will prejudice them in some of their transactions to the extent of from ten to thirty shillings per ton. It is stated that they have drawn up an alternative gauge for the consideration of the Board of Trade.

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THE MAGNETOPHONE*.

By Prof. N. S. Carhash, of Evanston, Illinois, U.S.

The experiments of Bell, Preece, and others, on the radiophone suggested the possibility of interrupting, or at least periodically modifying, the lines of force proceeding from the poles of a magnet, by means of a disc of sheet iron, perforated with a series of equidistant holes, and rotated so that the holes should pass directly in front of the magnetic pole. It is well known that the armature placed on the poles of a permanent magnet diminishes the strength of the external field of force by furnishing superior facilities for the formation of polarised chains of particles from pole to pole. This is the case even when the armature does not touch the poles, but is in close proximity to them.

If a piece of sheet iron be placed over the poles of a magnet without touching, and magnetic curves be developed in paper above the iron, they will be found to exhibit less intense and less sharply defined magnetic action than when the sheet iron is removed. If, however, a small hole be drilled directly over each magnetic pole, the screening action of the sheet iron is modified in much the same way as when a hole is made in a screen opaque to light; for the developed curves show distinctly the outline of the holes. If, therefore, the sheet iron in the form of a circular plate, pierced with a number of holes, be rapidly rotated between the poles of a magnet and small induction bobbins, the action of the magnet on the core of the bobbins will be periodically modified, because of the passing holes; and hence induced currents will flow through a circuit including the bobbin.

A disc of sheet iron was pierced with two circles of quarter inch holes concentric with the disc, the number of holes in the two circles being thirty-two and sixty-four respectively. On one side of the disc was placed a horseshoe magnet with its poles very near the rows of holes; on the other side were arranged two corresponding induction bobbins. The circuit was completed through a telephone and either bobbin at pleasure. Upon rotating the disc rapidly, a clear musical sound was produced in the telephone, the pitch rising with the rapidity of rotation. Moreover, the bobbin opposite the circle of sixty-four holes gave the octave above the other, and each gave a note of the same pitch as was produced by blowing a stream of air through the corresponding holes.

A HISTORY OF ELECTRIC TELEGRAPHY TO THE YEAR 1837.

BY J. J. FAHIE, MEMB. SOC. TEL. ENGS. AND ELECS.†

Note.—Being anxious to make his History as complete as possible, the Author will be grateful to his readers for any information, no matter how small, in relation to the subjects treated of in these pages.

Chapter III.—Telegraphs Based on Static, or Frictional, Electricity.

(CONTINUED FROM PAGE 406.)

1825.—" Moderator's " Telegraph.

The following proposal of what may be called a physiological telegraph is extracted from the London *Mechanics' Magazine*, for June 11, 1825, page 148 :—

" Electric Telegraphs.

" Sir : There is, I think, in one of the numbers of the *Spectator*, dated about a hundred years ago, a passage tending to ridicule some projector of that day, who had proposed to 'turn smoke into light and light into glory.' This early idea of gas-light, to which it seems plainly to refer, was received as an idle dream, and is only preserved to us, like straws in amber, by the wit and satire of Addison, or Steele. We are to learn, therefore, not too hastily to reject even those hints which are not immediately clear to us.

" Under protection of this remark I venture to propose to you that a telegraphic communication may be held, at whatever distance, without a moment's loss of time in transmission, and equally applicable by day, or night, by means of the electric shock.

" An experiment of this kind has been tried on a chain of conductors of three miles in extent, and the shock returned without any perceptible time spent in its going round; and may not the same principle be applicable for 100, or 10,000 miles? Let the conductors be laid down under the centre of the post-roads, imbedded in rosin, or any other the best non-conductor, in pipes of stoneware. The electric shock may be so disposed as to ignite gunpowder; but if this is not sufficient to rouse up a drowsy officer on the night-watch, let the first shock pass through his elbows, then he will be quite awake to attend to the second; and by a series of gradations in the strength and number of shocks, and the interval between each, every variety of signal may be made quite intelligible, without exposure to the public eye, as in the usual telegraph, and without any obstruction from darkness, fogs, &c. It was mentioned before that electricity will fire gunpowder—that is known; we may imagine, therefore, that on any worthy occasion, preparations having been made for the expected event, as the birth of a Royal heir, a monarch might at one moment, with his own hand, discharge the guns of all the batteries of the land in which he reigns, and receive the congratulations of a whole people by the like return.—I am, &c.,

" Moderator."*

1825.—R. H.'s Telegraph.

In reference to the letter which we have just given from the *Mechanics' Magazine*, another correspondent " R. H.," wrote as follows in the number of the journal for June 25, 1825 :—

" The present telegraphic communication is effected by means of six shifting boards, in a manner with which your readers are doubtless conversant. Now, if it be practicable to lay down one wire, it will be equally practicable to lay down six; and the cost of the wire would be nearly all the difference in the expense. Let the wires terminate in a dark room. On one wall let there be the figures 1, 2, 3, 4, 5, 6, prepared in *tin-foil*, according to the method practised by electricians, in forming what are called *luminous modes and figures*. Bring the six wires in contact with the six figures separately. With this contrivance, all the signals may be performed, as at present with six shifting boards. A shake of the arm, as 'Moderator' suggests, may call the watch to his duty; and he could name the signals as they appear, to his assistant, as is the present custom in the established telegraphs. His assistant must, of course, be separated from the dark room by a slight partition, that should be proof against light, but not against the full hearing of the human voice."†

1826-7.—Dyar's Telegraph.

About this time Harrison Gray Dyar, of New York, constructed a telegraph which was of an entirely different character to any of those hitherto described, as it depended for its action on the power of the spark to effect chemical decompositions.

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* The Magnetophone, or the Modification of the Magnetic Field by the Rotation of a Perforated Metallic Disc. Abstract of a paper read at the Meeting of the American Association for the Advancement of Science, held at Minneapolis, 15th August, 1883.

† The author reserves all rights of translation.

* To the same class belonged the electro-physiological telegraph proposed by Vorsselmann de Heer, and exhibited by him at a meeting of the Physical Society of Deventer, on January 31, 1839. In this system the correspondent received the signals at his fingers' ends, by placing them upon the ten keys of a finger board, which, by means of separate line wires, communicated with corresponding keys at the distant station. The signals were indicated by sending an induction current through two of the wires, and the shocks were observed—(*a*) in one finger of the right and one of the left hand, or (*b*) in two fingers of the right hand, or (*c*) in two fingers of the left hand. The (*a*) shocks represented the letters of the alphabet, the (*b*) shocks, the ten numerals, and the (*c*) shocks, ten code, or conventional signs. See Vorsselmann de Heer's "Théorie de la Télégraphie Electrique," &c., Deventer, 1839, and Moigno's "Traité de Télégraphie Electrique," Paris, 1852, pages 90 and 364. Reading by shocks, taken on the tongue, or fingers, has long been practised as a make-shift by inspectors and linemen all over the world. Varley mentioned it in the discussion which followed the reading of Dr. (now Sir William) Siemens' paper before the Society of Arts, April 23, 1858. Quite recently (April, 1878), yet another form of physiological telegraph has been submitted by M. Mongenot to the French Academy, in which the transmitter and receiver are the same, and consist of two ivory plates carrying the disconnected ends of the two line wires. The sender places this contrivance between his lips, and sends the message by talking or by closing the circuit by his lips according to a code of signals. The receiver, holding the receiving apparatus similarly, interprets the message by the sensation he feels. This plan was, evidently, suggested by Sulzer's experiment of 1767. See his " Nouvelle Théorie des Plaisirs," page 155.

† A further communication on the subject was promised but never made. In the hope of finding some clue to the writers of these letters we have carefully looked through several succeeding volumes of the *Mechanics' Magazine*, but without success. We have, however, discovered in another place—" London Anecdotes, the Electric Telegraph," 1848, page 119—a statement which, whether *apropos* or not, we may fittingly quote here, seeing that it belongs to the same date. It is to the effect that " a Mr. Porter of Harrow memorialised the House of Commons on the subject of an electric telegraph, and, in 1825, proposed a method of instantaneous communication with outposts, which neither foggy weather, nor the darkness of night need prevent."

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This property of electricity was first observed about the middle of the last century, and, had chemical science attained then to a sufficiently advanced state, it could not have failed to lead to the discovery of electro-chemistry.*

Besides being an *electro-chemical* telegraph (although not the first), Dyar's invention had the great merit of being a (in fact, the first) *recording* telegraph, and a fairly perfect one to boot, and, had he only used voltaic, instead of static, electricity, the problem of electric telegraphy would have been solved in 1827. And, thus, with a start of several years, there can be little doubt that electro-chemical telegraphs would have made a better stand than they afterwards did in the struggle for existence; although, perhaps, there can be as little doubt that, in obedience to the inexorable law of the survival of the fittest, they must have eventually yielded to the more practicable electro-magnetic forms of Cooke and Morse.

In connection with one of the many telegraph suits in which Morse was long engaged in America, Dyar gave the following account of his early project, in a letter to Dr. Bell, of Charlestown, dated Paris, March 8, 1848:—

"Since reading your letter, and when searching for some papers in reference to my connection with this subject, I found a letter of introduction, dated the day before my departure from America, in February, 1831, from an old and good friend, Charles Walker, to his brother-in-law, S. F. B. Morse, artist, at that time in Europe. At the sight of this letter, it occurred to me that this Mr. Morse might be the same person as Mr. Morse of the electric telegraph, which I found to be the case. The fact of the patentee of this telegraph, which is so identical with my own, being the brother-in-law of, and living with, my friend and legal counsel, Charles Walker, at the time of, and subsequent to, my experiments on the electric telegraph in 1826 and 1827, has changed my opinion as to my remaining passive, and allowing another to enjoy the honour of a discovery, which, by priority, is clearly due to me, and which, presumptively, is only a continuation [resumption] of my plans, without any material invention [improvement] on the part of another.

* * * * * *

"I invented a plan of a telegraph, which should be independent of day, or night, or weather, which should extend from town to town, or city to city, without any intermediary agency, by means of an insulated wire, suspended on poles, and through which I intended to send strokes of electricity, in such a manner as that the diverse distances of time separating the divers sparks should represent the different letters of the alphabet, and stops between the words, &c. This absolute, or this relative, difference of time between the several sparks I intended to take off from an electric machine by a little mechanical contrivance, regulated by a pendulum; while the sparks themselves were intended to be recorded upon a moving, or revolving, sheet of moistened litmus paper, which, by the formation of nitric acid by the spark in its passage through the paper, would leave [show] a red spot for each spark. These so-produced red spots, with their relative interspaces, were, as I have said, taken as an equivalent for the letters of the alphabet, &c., or for other signs intended to be transmitted, whereby a correspondence could be kept up through one wire of any length, either in one direction, or back and forwards, simultaneously or successively. In addition to this use of electricity I considered that I had, if wanted, an auxiliary resource in the power of sending impulses along the same wire, properly suspended, somewhat like the action of a common bell-wire in a house.

"Now you will perceive that this plan is like that known as Morse's telegraph, with the exception that his is inferior to mine, inasmuch as he and others now make use of electro-magnetism, in place of the simple spark, which requires that they should, in order to get dots, or marks, upon paper, make use of mechanical motions, which require time; whereas my dots were produced by chemical action of the spark itself, and would be for that reason, transmitted and recorded with any required velocity.

* * * * * * *

"In order to carry out my invention I associated myself with a Mr. Brown, of Providence, who gave me certain sums of money to become my partner. We employed a Mr. Connel, of New York, to aid in getting the capital wanted to carry the wires to Philadelphia. This we considered as accomplished; but, before beginning on the long wire, it was decided that we should try some miles of it on Long Island. Accordingly I obtained some fine card wire, intending to run it several times around the Old Union Race Course. We put up this wire at different lengths, in curves and straight lines, by suspending it [with glass insulators] from stake to stake, and tree to tree, until we concluded that our experiments justified our undertaking to carry it from New York to Philadelphia. At this moment our agent brought a suit, or summons, against me for 20,000 dollars, for agencies and services, which I found was done to extort a concession of a share of the whole project.

"I appeared before Judge Irving, who, on hearing my statement, dismissed the suit as groundless. A few days after this, our patent agent (for, being no longer able to keep our invention a secret, we had applied for a patent) came to Mr. Brown and myself, and stated that Mr. Connel had obtained a writ against us, under a charge of conspiracy for carrying on secret communication from city to city, and advised us to leave New York until he could settle the affair for us. As you may suppose, this happening just after the notorious bank-conspiracy trials, we were frightened beyond measure, and the same night slipped off to Providence. There I remained some time, and did not return to New York for many months, and then with much fear of a suit. This is the circumstance which put an end [to our project], killing effectually all desire to engage further on such a dangerous enterprise. I think that, on my return to New York, I consulted Charles Walker, who thought that, however groundless such a charge might be, it might give me infinite trouble to stand a suit. From all this the very name of electric telegraph has given me pain whenever I have heard it mentioned, until I received your last letter, stimulating me to come out with my claims; and even now I cannot overcome the painful association of ideas which the name excites."

To this very interesting statement, Dr. Bell has added the following corroborative testimony:—"I was engaged with Harrison Gray Dyar for many months in 1828. We often conversed upon the subject of his having invented an electric telegraph, and I recollect seeing in his apartment a quantity of iron wire which he had procured for the construction of his telegraph. I recollect his saying he had suspended some of this wire at an elevation around the race course at Long Island, to a length which satisfied him that there were no practical difficulties in carrying it from New York to Philadelphia, which, he stated, was his intention. I recollect suggesting doubts whether the wire would bear the necessary straightening up between the posts, and his reply, that the trial on Long Island had proved to him that there was no difficulty to be apprehended in this direction. My impression, derived from his conversation, was that the electric spark was to be sent from one end of the wire to the other, where it was to leave its mark upon some chemically-prepared paper."*

In 1831 Dyar came to Europe on business connected with some of his mechanical inventions, and resided principally at Paris until 1858, when he returned to the United States for good. His connection with telegraphy is somehow little known to the present generation, although, in 1826-7 he was widely known, at least in America, for his electrical researches. It is satisfactory to learn that his pursuits in other departments of science brought him an ample fortune, which was largely augmented by real estate investments in the city of New York. Dyar was born at Boston, Mass., in 1805, and died at Rhinebeck, N.Y., on the 31st January, 1875.

(TO BE CONTINUED.)

DETERMINING THE INTENSITY OF MAGNETIC FIELDS.—ERRATUM.—In Mr. Gray's paper on the "Determination in Absolute Units of the Intensities of Powerful Magnetic Fields," which appeared in *The Electrician* for September 1, the commas after the words "and" and "disturbances," in lines 7 and 8 from bottom of p. 370, should be deleted.

* Beccaria, by the electric spark, decomposed the sulphuret of mercury, and recovered the metals, in some instances, from their oxides. Watson found that an electric discharge passing through fine wire rendered it incandescent, and that it was even fused and burned. Canton, repeating these experiments with brass wire, found that, after the fusion by electricity, drops of copper only were found, the zinc having apparently evaporated. Beccaria observed that when the electric spark was transmitted through water bubbles of gas rose from the liquid, the nature, or origin, of which he was unable to determine. Had he suspected that water was not what it was then supposed to be, a simple elementary substance, the discovery of its composition could scarcely have eluded his sagacity. Franklin found that the frequent application of the electric spark had eaten away iron; on which Priestley observed that it must be the effect of some acid, and suggested the inquiry whether electricity might not probably *redden vegetable blues?* Priestley also observed that, in transmitting electricity through a copper chain, a black dust was left on the paper which supported the chain at the points where the links touched it; and, on examining this dust, he found it to contain copper.—Lardner's "Electricity, Magnetism, and Meteorology," Vol. 1, pages 78-9.

* In these extracts we have followed "History, Theory, and Practice o the Electric Telegraph," by George B. Prescott, Boston, 1860, pp. 427-30; "Historical Sketch of the Electric Telegraph," &c., by Alexander Jones, New York, 1852, pp. 35-7; and *The Telegrapher*, New York, Vol. 1, pages 48 and 163.

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THE ELECTRICIAN.

TO CORRESPONDENTS.

All letters intended for insertion in THE ELECTRICIAN, *or containing questions, must be accompanied by the name and address of the writer. not necessarily for publication, but as a proof of good faith. No notice whatever will be taken of anonymous communications.*

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ANSWERS TO CORRESPONDENTS.

E. H. WILLIAMS.—*Cannot give you any information as to the electro-therapeutic bath, but have inserted your query in our notes.*

C. E. MELLISH.—*Since writing the answer published in our last issue, we have ascertained that the cylindrical tray used in the battery referred to by you is made of iron.*

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THE CITY AND GUILDS OF LONDON INSTITUTE.

It is only natural that the institute in its report upon the recent examinations and the progress of the work attempted should see cause for self-congratulation. It is satisfactory certainly to find that the number of candidates for examination shows a considerable increase, but the increase in the percentage of successes is almost infinitesimal, for whereas in the 1882 examinations 1,222 out of 1,972 candidates passed, in May last there were 2,397 candidates examined, of whom 1,498 were successful, showing percentage failures of 38 and 37·5. This is scarcely as it should be, for we ought most decidedly to see a much lower percentage of failures than is here indicated. Judging from the report, a more than cursory inquiry has been made into the cause of the large percentage of failures, and as is usual in such cases, blame is, often only too truly, laid through a by-thrust upon the teacher. The report declares that "considerable difficulty is still experienced in finding competent teachers for technical classes, possessing both a practical and a scientific acquaintance with their subject." We are not in a position to judge of the merits or abilities of those engaged in imparting technical instruction to classes, but of one thing we are certain, and that is that if we wish for a good article we must be prepared to pay a good price for it. In the programme for the session the names of 377 teachers were published, and 1,132 candidates belonging to the 154 centres were successful, the remaining 366 successful candidates being "self-taught." The figures show an average of £3 per teacher, or about 2s. per lecture, reckoning 30 lectures to constitute a course. It requires very few, if any, words to demonstrate the necessity for a change to be made in the manner or quantity of aid afforded to the classes. Furthermore, it may be pointed out that the maximum grant awarded upon one individual in three years by the Science and Art Department is £8, whereas under the Technological Institute one-half only of the amount is attainable. Again, we may observe that a candidate may be presented for examination by the South Kensington professors in five subjects each year, but rarely can a student sit for more than one technical subject. It is clear, then, that if the help awarded by the institute is to be regarded as a real one, it must by some means be so arranged as to make it worth the while of "competent teachers" to undertake the work. It might be suggested that the three-grade system should be resorted to, as there is manifestly a wide gulf between the apprentice for whom the "ordinary" examination is intended and the expert to test whom the "Honours" papers are designed. A differential syllabus, that is to say one which enumerates the various branches and portions of the subject to be studied for each examination, would also be a great boon to teachers. We observe this very pointedly in the electric lighting, telegraphy, and kindred examinations. Teachers have at present to ramble wildly over the whole subject, or, as we know some do, confine themselves to a small section and trust to chance, or leave the students to make up the rest if they are so minded.

There is one more point upon which we would say a word or two. There is a regulation in the programme to the effect that to obtain a "full" certificate on a subject it is necessary to have passed, either in the same or in a previous year, two of the South Kensington examinations. Those who fail in this latter respect have to derive what satisfaction they can from a partial or provisional certificate. It is estimated in the report that of the 1,498 candidates who were successful in the technical examination only 420, or 28 per cent., have gained the full certificate. How far the obligation to pass the more theoretical examinations of the Science and Art Department is likely to further the object of the institute is by many regarded as an open question. For our part we should be slow to recommend abandoning the regulation, which must enhance considerably the value of a full certificate, and we should be disposed to say that the student or workman who declines to answer a paper set by the South Kensington professors "because it is degrading" exhibits a highly reprehensible spirit. As a matter of fact, our opinion is, in spite of what may be said to the contrary, that there are few, if any, *bonâ fide* workmen who possess this failing. One thing, however, is beyond dispute, and that is, that all should be treated alike. It is manifestly unfair that, while it is obligatory for the candidates examined in the majority of schools to pass the qualifying science examinations, those candidates examined at a few favoured institutions should be exempted from this "degrading" portion of the task on the production of a certificate of general efficiency from the particular centre in which the technological subject was taught. Even this, however, could be tolerated were it done conscientiously,

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But what teacher or secretary is there who would not be tempted to strain a point to grant the necessary certificate, and so gain glory to the school, even though it did occasion a feeble twinge from the still small voice within? That our surmise on this point is warrantable is proved by a little incident that has come under our notice. In this particular case the candidate, who had never sat for examination under the Science and Art Department, applied to be examined by the institute at one of the privileged schools. He had never attended a lecture on the subject, but was, notwithstanding, awarded a valuable prize and medal, for which, however well he might have worked his technological paper, he would have been disqualified had his name appeared amongst those of any unprivileged school. The hardship incident upon the great majority of candidates is, especially as the prize papers are competitive, a real one, and we earnestly hope that the regulation will be at least modified.

We would not have it supposed that what we have said has been animated by a spirit of carping criticism. The institute has certainly engaged in a good work, and our one effort is to increase the valuable results of that work by pointing out little and easily-remedied defects in the system.

THE INTERNATIONAL ELECTRICAL EXHIBITION AT VIENNA.

(FROM OUR SPECIAL CORRESPONDENT.)

II.

Our previous letter was sent after a short look through the exhibition, but not before we had been laughingly informed of the eccentricities of the correspondent of *The Times*. It is but just to say that Professor G. Forbes, who is at Vienna, and who was *The Times* correspondent at Paris, is not the correspondent at Vienna. Professor Forbes would in any case understand the subject upon which he was writing, however it pertained to electrical matters; but the members of the English colony at the Vienna Exhibition are of the opinion that a superficial smattering of electrical knowledge is a dangerous thing for a special correspondent. However, we are not answerable for the sins of *The Times*, although it disgraces English scientific journalism. To resume our description of the exhibition, we may ask, in the first place, to be allowed to ignore any regular order, and describe the exhibits in a somewhat disconnected manner. This is necessary inasmuch as diagrams take time to prepare, and cannot always be obtained at the wished-for moment. One of the largest exhibits is that of

The INTERNATIONAL ELECTRIC COMPANY, formerly known as the Austrian Brush Company. This company is really of English origin, carrying on business in Austria and Roumania under concessions granted by the respective governments. The exhibit consists in the first place of 80 arc lamps of the Brush type, with current supplied by two No. 8 Brush machines. Each of these machines supplies the current to 40 lamps in series. The 80 lamps are distributed as follows:—40 are suspended from the balcony of the Rotunda, extending round one half of its circumference, 8 are placed in the North Machine Gallery, 6 at the entrance to the gallery, 7 under the arcades of the south front of the building, 10 on posts along the eastern side of the building to light the carriage stand, and 9 lamps light the boiler house. At least, such was the distribution on our arrival at Vienna, but owing to the violence of the wind on Sunday night, September 2, two iron lattice-work masts, each with four arc lights at the top, were blown down. The masts were not stayed, and the arrangement was top heavy, although the high wind at the time would have severely tested any mast. To replace the lights on these masts the International Company was asked to move 10 lights from the east end to the front. The request was made at midday, and their lights were running in the evening, work which reflects great credit upon the organisation of the staff. The 40 lamps around the balcony are of the ordinary workshop pattern, the remainder have a more ornamental casing, as shown in Fig. 1. The casing of this lamp is nickel plated, with an elliptical globe, the whole being designed and made at the Vienna

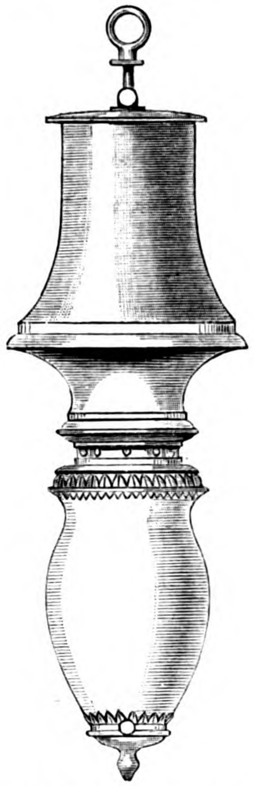

FIG. 1.—Ornamental Casing and Globe for Brush Arc Lamps.

Works of the company. The lamps work, we are told, with a current of about 10 amperes, and have copper-plated carbons, 11 mm. diameter. The average length of arc is said to be about 2 mm. The forty-lighter Brush runs at a speed of

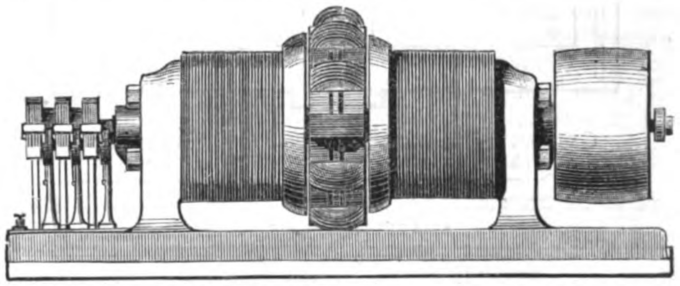

FIG. 2.—New Pattern Brush Dynamo—Front View.

about 750 revolutions, generating the required current at an E.M.F. of 2,200 volts. This makes the resistance of each lamp (neglecting the resistance of the leads as above) 5·5 ohms.

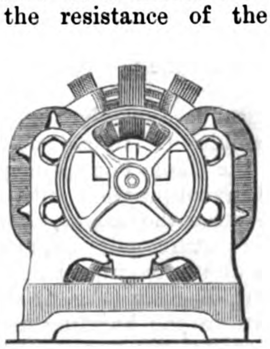

FIG. 3.—New Pattern Brush Dynamo—End View.

The frames of these machines differ somewhat from those of the old American pattern in that they consist of a solid casting. Figs. 2 and 3 will show this.

In connection with these arc lights the company exhibit

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two kinds of current regulators, having for their object to vary the E.M.F. proportionately to the number of lamps to be switched on and off, without varying the speed of the engine or dynamo. One of these regulators is worked automatically and the other by hand. Both are based on the principle of inserting a variable resistance in parallel circuit with the coils of the field magnets of the machine, by which means a portion of the exciting current is "shunted," and the intensity of the magnetic field, in which the armature revolves, reduced in a greater or less degree. The resistance used in both forms of regulator is that known as "carbon contact," and is composed of a large number of small carbon plates laid one upon another, which are more or less compressed, by a screw and hand wheel in one case, and by the action of an electro-magnet upon its armature in the other or automatic regulator. In this latter form the coils of the operating electro-magnet form a part of the external or lamp circuit, and its action is explained as follows:—Supposing a lamp to be switched out, the resistance of the external circuit is reduced; this causes a certain increase of current to circulate, and the regulating electro-magnet to more powerfully

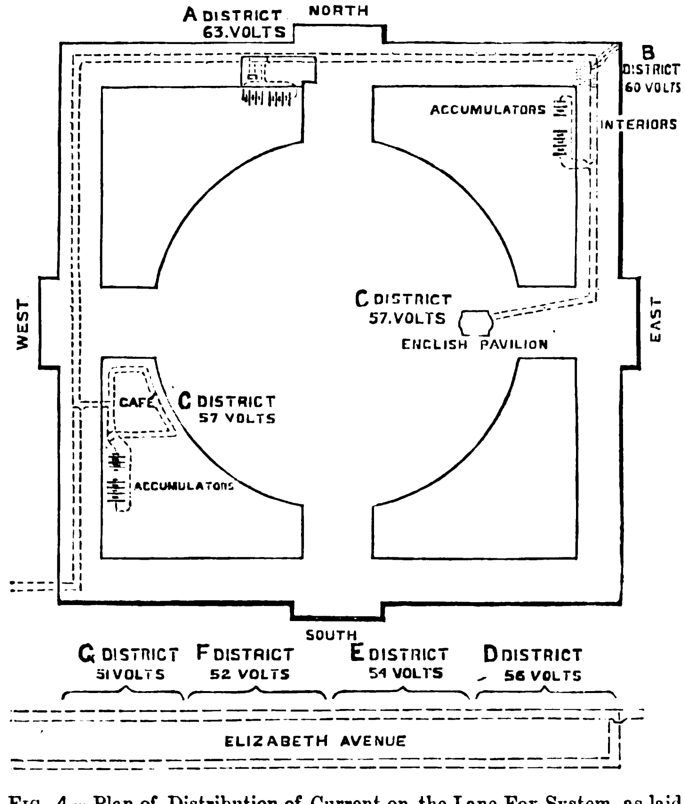

Fig. 4.—Plan of Distribution of Current on the Lane-Fox System, as laid down at the Exhibition by the International Electric Company. The Dotted Lines represent Circuits.

attract its armature. This power is utilised by means of a lever to increase the pressure upon and reduce the resistance of the carbon resistance, thereby shunting a larger portion of the exciting current past the field-magnets until the normal state of things is restored.

For lighting by incandescence the company has two systems laid down in the exhibition. In one the distribution of current is effected on the Lane-Fox principle, and comprises accumulators used in conjunction with the generator and lamps, while in the other the lamps, about 200 in number, placed in one of the picture galleries, are fed direct from a Ferranti-Thompson alternate current machine.

The accompanying diagram (Fig. 4) shows the Lane-Fox system as laid down in the building and approaches, and forms an excellent typical illustration of the way in which it would be applied for the distribution of electric energy over a large area.

In this installation the generators are six in number, all worked in parallel or multiple arc between the main and return conductors. Two of these are of the Brush type, No. 6 size, excited by a smaller machine of the same pattern, No. 4 size. Two more are modifications of the well-known Schuckert type. They are self-exciting shunt-wound machines, and the remaining two are the compound Bürgin.

The accompanying diagram (Fig. 5) will illustrate the way in which they are connected to the main conductors, and shows how the current from each machine may be instantly measured. Any one machine may be turned on or off, and the whole system regulated from one switch board or regulator box. The entire system is controlled by a variable resistance placed in the field-magnet circuit of the two No. 6 Brush machines, which it will be remembered are excited by a separate machine. This resistance is sufficient to vary the energy given out by these two machines to a greater extent than the entire capacity of any one other machine in the system, and therefore, when it is required to increase or diminish the supply, one or more machines can be switched in or out, and the "fine adjustment," as it may be called, effected by the variable resistance mentioned above.

Thus, an entire installation comprising some hundreds of lights is placed completely under the control of one man, in one place, who can with a turn of the hand switch machines or lamps in or out, and control the system, extending perhaps over some miles.

The area over which the distribution is effected is, as may be seen, mapped out into different districts according to the average difference of potential between the two conductors in it.

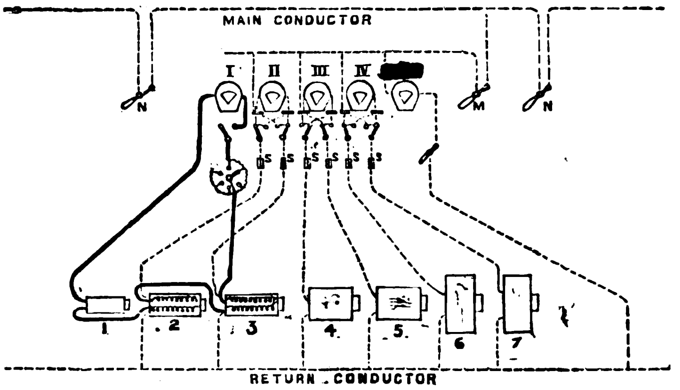

Fig. 5.—Plan of Connections, with Switchboard, for the Lane-Fox System of Distribution. In this plan, 1 is a No. 4 Brush machine, used as an exciter; 2 and 3 are No. 6 Brush machines, 4 and 5 are C Schuckert machines, and 6 and 7 Bürgin machines. I. represents an ammeter in the exciting circuit (which is indicated by black lines, the other circuits being represented by dotted lines), II., III., and IV. are ammeters in machine circuits, V is a voltmeter, *s s* fusible safety plugs, M main switch, and N N two branch switches.

At the poles of the machine, *i.e.*, in the machine room, marked A in figure 4, this difference of potential, or E.M.F., is 63 volts. In the B district, comprising several furnished rooms and passages leading thereto, this E.M.F. is reduced to 60 volts; in the C and C 1 districts, comprising the pavilion of the British Commission and the garden adjoining the restaurant, it is further reduced to 57 volts, while in the long street or avenue there are four different districts, viz., D E F and G, working respectively with E.M.F. of 56, 54, 52, and 51 volts.

It may be here mentioned that in this portion of the system the fall of E.M.F. is much greater than would in practice be arranged in a permanent installation, the question of cost of conductors playing an important part in a temporary installation of this magnitude laid down solely for exhibition purposes. The number of lamps used on this system is approximately 400, arranged—A district 80, B 150, C 50, D E F and G 70. An interesting feature of the D E F and G districts is the use of an earth return, *i.e.*, an uninsulated conductor buried in the ground. This is believed to be the first experiment of the kind made with incandescent lighting, and so far gives promise of success.

The accumulators shown at districts A, B, and C are modified Plantés, the modifications being made by Mr. St. G. Lane-Fox. We show in Fig. 6 the switch used with the incandescent lamps. We believe this switch—as were, indeed,

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most of the accessories—was designed by Mr. J. G. W. Fairbairn, the manager of the Vienna works, where the whole of the apparatus exhibited was manufactured. In the figure, W and B represent two pushes, respectively coloured white and black. S S are springs. Pushing W brings the springs into contact, and completes the circuit, while pushing B breaks the circuit. A large switch (Fig. 7) is used, which is slightly different to the usual switches. Figure 8 shows the Lane-Fox lamp and holder. V is a plug of vulcanised fibre. S S are the springs making contacts with the screws, which are in contact with the conductors. C is

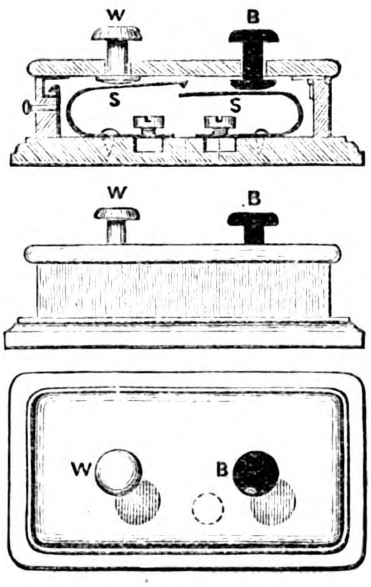

FIG. 6.—Fairbairn's Switch.

the filament of carbon. The lamp is well made. The arrangement of this exhibit is due to Mr. H. W. Wollaston, the company's chief electrician, and has been carried out by Mr. G. Cotham, who had previously carried out the lighting of the opera here, an installation which we have examined, and about which we may have something further to say.

Passing from the practical work of lighting to theoretical

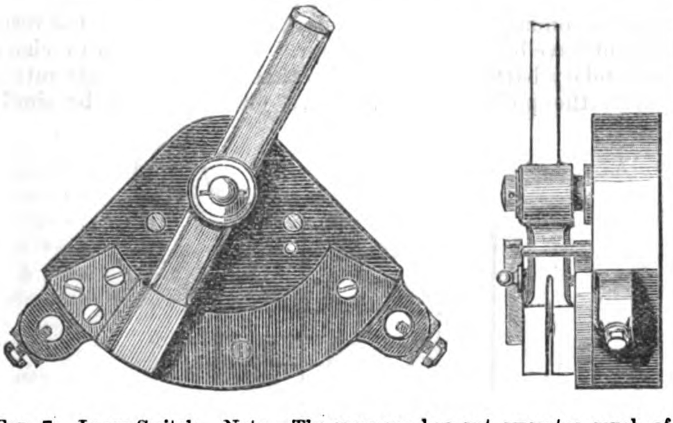

FIG. 7.—Large Switch. Note.—The engraver has cut away too much of the upper portion of the contact-bar. It should extend from the three screws on the left to, at least, the middle of the arc, the contact-maker sliding under it.

work of another kind, we may notice the exhibit of Professor Dvořak. This exhibit recalls to mind the work of Professor Hughes which resulted in the induction balance, and of a large amount of other work by Professor Hughes which is waiting to be applied; it reminds us of Bjerkness's experiments at Paris, and of Stroh's continuation of these experiments, so admirably described and illustrated to the Society of Telegraph Engineers. Professor Dvořak's apparatus is, like that of these master experimentalists, of a simple character. Its most important parts consist of a tuning fork, which, set in motion, is sustained in motion by an electric current, and a second tuning fork, placed upon a sound chamber; the second fork being connected electrically with the first, the sounding chamber intensifies the sound till it fairly becomes a musical roar. Fig. 9 shows roughly the former, and Fig. 10 the latter part of the apparatus. Professor Dvořak gave a lecture describing his apparatus, illustrated by experiments. The most interesting feature was that the sound waves seemed to be converted into *continuous* air waves. Thus, light bodies placed in front of the orifice of the sounding-

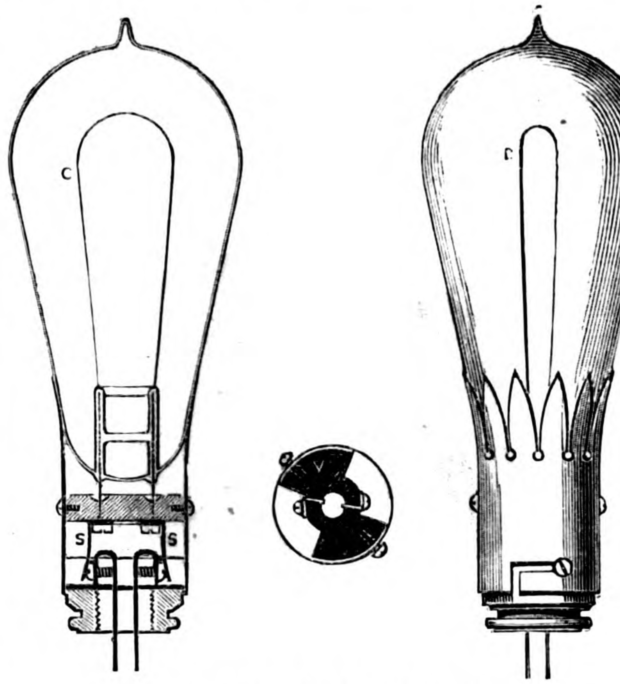

FIG. 8.—The Lane-Fox Incandescent Lamp.

box were rapidly rotated, and a hollow pear-shaped brass ball, having a hole at the stalk end about a centimetre in diameter, and a hole at the other end about a millimetre in diameter, placed with its larger opening towards the orifice, gave out a continuous air current from its smaller opening, and this whether placed at a distance of an inch or two or a foot or more. Similarly, balls and light flags were repelled from the orifice, of course more strongly when nearer than when further off.

Close to Professor Dvořak's exhibits are a number of

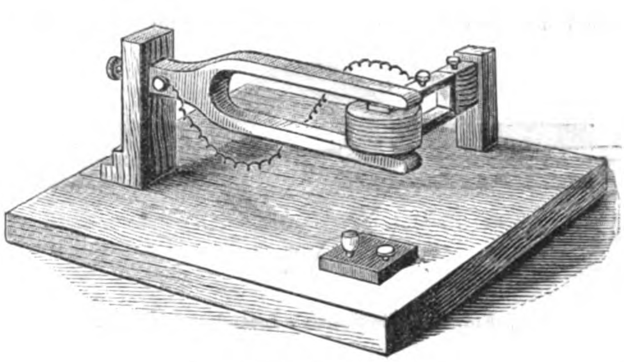

FIG. 9.—The Transmitter.

lecture models, among which is one shown by Dr. A. WALTENHOFEN, being for the purpose of illustrating the effect of a magnetic field upon a conductor passing through it.

One of the most, if not the most interesting exhibit to those engaged in electric light work is the archæological apparatus of Lodyguine and others, shown in the Russian section. The exhibit marked 23 in this section is the lamp of M. Khotinschy, of 1872. The carbon is hermetically sealed in a small globe of glass. The globe is about 3cm. diameter, and the carbon, estimated by sight, may be from 1 to 1·5mm. diameter. In Fig. 11 C shows the carbon, *Cd* the conductor,

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G G the glass globe, and S the point where the globe was sealed. Besides this lamp those numbered 24-5-6-7-8 are lamps of Flozensoff, of which Nos. 27-8 approach most nearly to the present form of incandescent lamp. Fig. 12 is a rough representation of lamp No. 27. G G shows the globe, C C the carbon, which is broken, C*d* C*d* the conductors. The glass globe is nearly 4cm. diameter, the carbon about the same size as that in previous diagram. Lamp marked No. 29 is that of Lodyguine. All these lamps were made in 1872. The difference between these lamps and those now in use is to be found in the exhaustion now carried out, and in the difference in the diameter and length of the carbons, the length of the carbons in the lamps illustrated being little more than a centimetre. No. 30 is another lamp of Lodyguine, of the

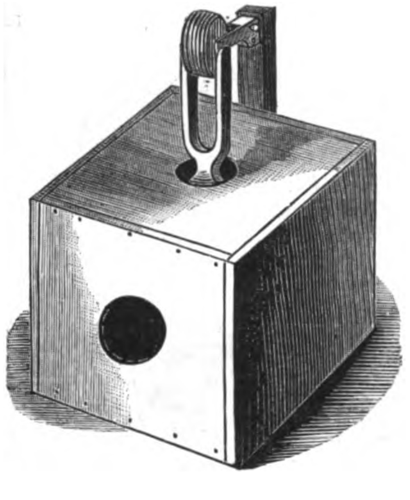

Fig. 10.—The Receiver.

date 1873, and it may be claimed for this lamp that it is the parent of the semi-incandescent lamps, such as those of Werderman, Joel, &c. Just by these lamps another phase of applied electricity is shown in the application to bleaching by the process of Lidoff and Tichomiroff. The current is used electrolytically to liberate the bleaching agent, and it is claimed that far better work can be done, inasmuch as the quantities required of the bleaching agent, and the temperature, can be far better regulated than under the ordinary system.

Adjacent to this exhibit is one consisting of a couple of cells of a scondary battery, with specimen plates. The plates are modifications of Planté's type, the porosity being obtained by means of the sand blast, the action of nitric

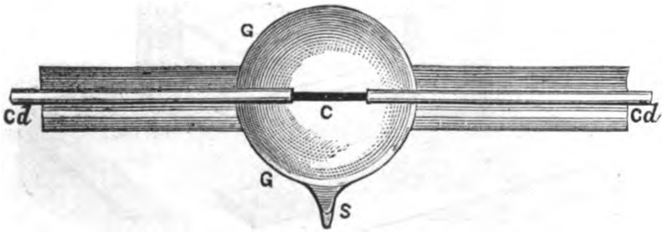

Fig. 11.—Khotinschy's Incandescent Lamp.

acid, or surfaces, augmented by extensive lamination. The plates are separated in the cells by means of strips of glass. Whilst upon this subject of secondary batteries we may as well refer to the exhibit of the Electrical Power Storage Company, which is by far the most extensive exhibit of secondary batteries. A wooden house has been fitted up with tiers of shelves in the North-west Court, and upon these shelves are placed the Sellon-Volckmar cells. These cells are well known, but one or two modifications have been recently introduced which tend to diminish the accidents to which these plates are liable. Thus, in the two horse-power cells the tangs of the gridded plate are formed into hooks, the plates hanging by these hooks, and plugs of india rubber are used to keep the plates apart. The glass-containing vessels are somewhat larger than the plates, and a free space is left around and below the plates, thus allowing for expansion. It is hoped that the "buckling" of plates will be avoided by hanging, and that the plugs will keep the plates from touching, and thus short-circuiting. In Fig. 13 H shows the hook-shape tang, which is on the one side or the other, according as the plate is to be positive or negative. The plates, as is well known, are cast in lead, in the form of a grating. The perforations, A A A have $\frac{3}{8}$in. side, while the lead between is about $\frac{1}{8}$in. The shaded squares BBB represent the plugs of india rubber, which stand out about $\frac{1}{8}$in., so that these plugs cause a space between the plates about $\frac{1}{4}$in. In the two h-p cells there are 24 plates, 12 connected together to form the positive plate,

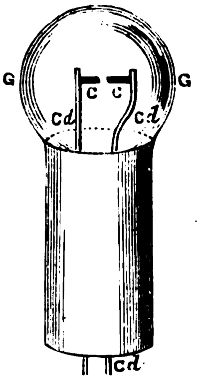

Fig. 12.—Flozensoff's Incandescent Lamp.

and 12 connected to form the negative plate. The other perforations in the plates are filled with red lead, flush to the surface of the grating. The electrolyte is dilute sulphuric acid. A horse-power is reckoned as 350 amperes under the E.M.F. of one cell. We may here say that a large number of similar cells were in use at the electric light installation at the Opera House here, and proved to be of great use. We have always contended that machinery must at some time or other come to grief, and at the Opera House, when a belt came off, as once happened, or the engine was stopped, as was necessary once, the light continued just as before, no one out of the engine house being one whit the wiser, nor did fear come near the audience, because there was no change in the light. Had there been no "secondary," and sudden darkness taken place, the result might have been a great disaster. It is preferable to charge secondary batteries in series, so that the chemical alterations upon the positive and negative plates should be similar

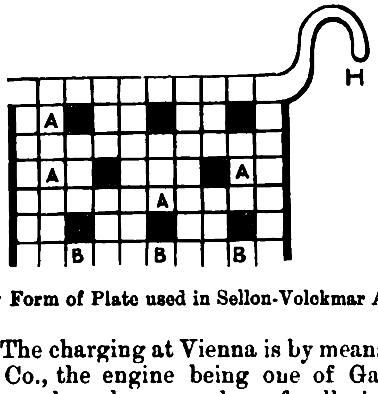

Fig. 13.—New Form of Plate used in Sellon-Volckmar Accumulators.

throughout. The charging at Vienna is by means of machines of Ganz and Co., the engine being one of Garrett's. The Storage Company has also a number of cells in the yard of the restaurant.

The application of secondary batteries to other purposes than electric lighting is shown; for example, a tricycle which can be driven by cells coupled to a motor is to be found, usually put at the back of the British pavilion, at other times in motion through the building. The driving wheels of the tricycle are 44in. diameter and are 42in. apart. A double set of brushes is provided, one pair being in contact with the commutator for motion forward, the other being put into contact for motion backward. There is also on the Danube canal the electrical boat mentioned by us at

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the time of its trial on the Thames; but of this we will speak more after a trip upon it. Altogether the company has tried to show the practicability of secondary batteries for various purposes.

"ELECTRICITY AT THE BOARD OF TRADE."

Legislation on a subject of a technical character in which the very measures and nomenclature employed are hardly settled by those who most use them is not likely to go very smoothly at first, or during the time which must elapse while uninstructed and inconsiderately appointed officers are struggling to do something while the thing is in the stage best described as that in which every one admits "something must be done," though that something may have, for all the positive help most people can give, to be arrived at by a sort of negative tentation. The Electric Lighting Act has been pushed through, and the Board of Trade has published various documents in the attempt to shake things into something like order by finding out what is wanted. "We propose to do, or allow so and so, what do you think?" is the style of one of the paragraphs by which the Board of Trade has felt its way. This sort of thing is, of course, absolutely necessary, for electric lighting or electric engineering generally is a subject that even the best intentioned Board of Trade officers cannot master in a month, and the admission of a certain amount of weakness in this direction is commendable, and should not be forgotten by those who think it would be better for the Board of Trade to appoint officers who know a little of the matters upon which they may now be frequently called upon to decide. It is not only in this direction, however, that the new Act goes a little roughly, and meets with very adverse criticism. We all wanted the electric lighting act settled as far as possible, so that work could be done. We cannot expect that the Act will be perfect in every particular. It becomes the duty, however, of all interested in the matter to point out in what respect improvements may be made, as there is no doubt that an Electric Light Amendment Act will before long occupy parliamentary attention, and it will not do a second time to be in the position of a person who has not yet found out his requirements. At present it seems that the Act puts things very much into the "undertakers'" hands, and the Board of Trade, which has very wide powers under the Act, is not, for want of properly-trained officers, in a position to make the best use of these powers. Some of the rules under which electric lighting companies or undertakers are to work are received with undisguised ridicule, and corporations are beginning to fear that in some matters they are quite at the mercy of the undertakers, as Londoners were at that of the gas companies prior to the regulating Act. That the new Act should have numerous flaws is, we think, not surprising, but the best must be done to make it work well and to make the best use of the powers conferred on the Board of Trade. Mr. Thomas H. Blakesley, M.A., has written a pamphlet entitled as above. It is published by Messrs. Sampson Low and Co., and will no doubt be followed by others drawing attention to the weak points in the Act, and in the rules and regulations. It draws attention to the way in which electric lighting companies, as the rules stand, may carry a current to a street, but if householders want it carried along the street the company is at liberty to do so if it pleases, not otherwise. The householder must extend it himself, and the cost will have only a minimum limit, as cross section must be in accordance with the rules which give minimum limit by stating maximum resistance. The rule as to electromotive force, and that as to maximum current of 750 amperes per square inch of section, those as to estimating supply, as to continuous and alternate currents, and other questions occupy the pages of Mr. Blakesley's pamphlet; but to enter into them critically would take as much space as does the said pamphlet, and therefore we must recommend our readers to get it. Every one should be fully acquainted with the defects of the new Act and the rules, in order that what reforms are needed may be definitely stated when the time comes.

SUBMARINE MINES.

During the American War submarine mines did great service as coast and harbour defences, and since that time they have been made the subject of considerable study by military and naval men of all nations. At the time of the Franco-German War, the Germans kept the French fleet away from their ports chiefly by this means of defence, and there can be no doubt that their importance for harbour protection can hardly be over-estimated. The Americans, with their great extent of sea-coast, studded with important and flourishing towns, and their small navy, have naturally made submarine mines and torpedoes a special study. Indeed, we have before us a recent report on the subject made by Lieut.-Colonel Henry L. Abbot, of the U.S. Corps of Engineers, which deals with the experiments and investigations made to develop a system of submarine mines for defending the harbours of the United States. This report contains details of a number of different experiments, valuable formulæ, descriptions of electrical apparatus for firing mines, and other information highly interesting to military and even ordinary readers. We propose, therefore, to extract from this report such information concerning the electrical apparatus therein described as we think will prove useful and interesting to our readers. We shall deal first with that class of firing apparatus described under the heading

Magneto-Electric Apparatus.

Magneto-electricity—*i.e.*, electricity generated by magnetism, has of late years received much attention; and so great improvements have been introduced in the apparatus that, for certain classes of practical applications, it bids fair to supersede the voltaic cell. Through its agency mechanical energy may be transformed into electricity of almost any desired potential and quantity.

The fundamental principle upon which this mode of generating electricity depends is identical with voltaic induction. Indeed, according to the accepted theory, the phenomenon of magnetism is due to a series of electrical currents, circulating around the molecules in a common direction, and the resultant of the effects of such a system is equivalent to that of a single current circulating round the exterior of the magnet. Facing the north-seeking pole, the direction of this resultant current is contrary to that of the hands of the watch; facing the south-seeking pole it accords with their direction.

Adopting this theory, let the north-seeking pole of a magnet be inserted by successive movements into a continuous ring of wire. According to the laws of voltaic induction an instantaneous current of electricity will be induced in the ring at every motion, their direction when looked at from the side in which the magnet is inserted being the reverse of that of the hands of a watch. Withdrawing the magnet in the same manner instantaneous currents will be excited in the same direction as that of the hands of a watch.

If the south-seeking pole be approached to or withdrawn from the ring, similar currents, but reversed in direction, will be induced. If, now, the single ring be replaced by a special coil, and the magnet be moved as before, the currents induced will be characterised by higher potential, their direction being the same as before.

If, instead of moving the magnet, a piece of soft (unmagnetised) iron be permanently inserted in the spiral, and by rapid contacts with the pole of a magnet be successively magnetised and demagnetised, instantaneous electrical currents will circulate as before. If the poles of a permanent magnet be extended by soft iron rods, surrounded by helices of wire, and the armature be applied, or withdrawn suddenly, currents in these helices will be developed by the resulting change in the locus of maximum magnetic intensity.

Upon these fundamental principles are based all the varieties of magneto-electric apparatus, their differences consisting simply in different mechanical devices for effecting magnetic changes within or near a coil of insulated wire.

If currents of high potential are desired the coils are made of fine wire, while if large quantity is needed coarse wire is used. In either case it must not be forgotten that the *duration* of the current is very short, and that, if a con-

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tinuous succession of waves approximating to a continuous current be desired, a very rapid succession of contacts and breaks must be provided. The current will then consist of a succession of waves in opposite directions, which, however, by the aid of what is called a commutator, may, if desired, be caused to coincide in direction. Thus modified, magneto-electric currents become very similar in their effects to those obtained from a voltaic battery.

The electricity generated by magneto-electric machines has a lower potential than that given by frictional and voltaic induction apparatus; indeed, it more nearly resembles, both in potential and in quantity, the voltaic current from many cells coupled in series. It is therefore less liable to escape through defects of insulation in the leading wires than that obtained from the machines already described; but, on the other hand, it exacts more attention to guard against small breaks in the continuity of the current.

Magneto-electric machines may be classified according to the form in which the force is utilised. Thus, in the progress of invention, instruments were made which acted (1) by a single wave; (2) by a succession of waves alternating in direction; (3) by a current more or less unvarying. It may be added, that by the device called a commutator, an alternating current may always be transformed into one pulsating in a single direction, thus transferring the instrument from Class (2) to Class (3).

The following tabular classification, based on the foregoing analysis, exhibits the magneto-electric igniting machines in most common use:—

I. Acting by single electric wave.	Breguet. Jürgensen. Marcus.
II. Acting by a succession of waves alternating in direction.	Wheatstone. Beardslee.
III. Acting by a continuous current.	Class II. with commutators added. Gramme.

It may be remarked, in general terms, that Classes I. and II. require medium tension, and Class III. low tension fuzes; but each kind of instrument, as a rule, has peculiarities which render it important to select its fuze with judgment. High tension fuzes can hardly be used with any variety.

In order to convey a fair idea of the relative power and convenience of these several machines for different classes of practical work, the following description of them is added. It will enable the officer to select the one best suited to his needs in any special case. The dimensions refer to sample instruments belonging to the School of Submarine Mining at Willets Point, and are the results of careful measurements. The plates are designed to explain the electrical principles, not the mechanical details of the apparatus.

The Breguet Machine.—This instrument consists of a

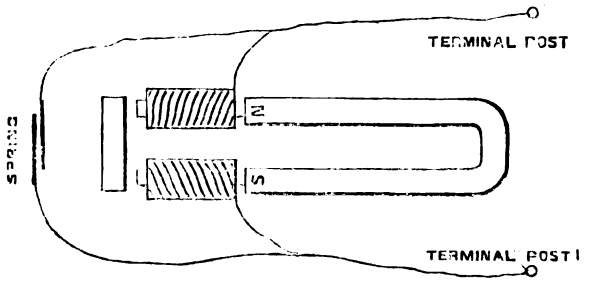

FIG. 1.—Breguet's Firing Apparatus.

horseshoe magnet, the poles of which, prolonged with soft iron, constitute the cores of two induction coils of very fine insulated wire, having a resistance of 9,400 ohms. A soft iron armature in contact with the ends of these cores is attached by a brass plate to a lever extending outside the case. This lever is so pivoted on a horizontal axis that a smart blow will separate the armature suddenly from the poles, and thus cause a current, induced by the change in the levers of magnetic polarity, to circulate through the coils. This current is greatly intensified by an extra spark caused by the following ingenious device: The coils are united in series, and the circuit is extended to two terminal posts outside the case; another circuit, forming a shunt between the coils and the terminal posts, consists in part of a spring attached to the lever and moving with it. After moving a certain distance, this spring breaks the shunt circuit, thus producing a strong extra spark by the interruption of the current at its maximum. It is chiefly this spark which passes through the exterior circuit and fires the fuzes (see Fig. 1).

The instrument is encased in a neat box, 18in. by 7in. by 6in. high, the whole weighing 21lb. A sliding key blocks the lever when not in use, and thus guards against accidents from careless handling. A switch and five posts on the cover allow any one of five torpedoes to be fired at will.

A tension fuse possessing a decided conductivity, like those of Abel or Von Ebner, is required with this machine; and to effect simultaneous explosions it is well to select fuzes nearly alike in this respect. This may be done by noting the deflections of a delicate galvanometer included with the fuze in the circuit of a small battery. Of course, fuses must be coupled in series with this class of machines, but where more than one fuze is used some other class should be selected. Sweden at one time adopted the Breguet apparatus for naval uses, but ultimately decided it to be deficient in quantity—especially for submerged cables, in which electrification largely reduces the volume of the spark. It is stated that on a land line, in 1869, a fuze was fired at a distance of 300 miles by this machine.

It is not easy to establish a standard by which to compare different kinds of igniting apparatus acting by a single wave, for the reason that the instruments differ both in the quantity and the potential of the charge; and the latter element passes from zero through an unknown maximum back to zero in a time immeasurably short. If, however, fuzes having a suitable conductivity are to be employed, an approximate idea of the relative power of two machines may be derived from a galvanometer measurement based upon the following principles:—

If the currents to be compared be instantaneous, and the needle be so heavy as not to move sensibly during the passage of the waves through the coils, the observed swings of the needle may be regarded as the effect of blows.

In this case the mechanical work is proportional to the versine of the angle of swing (a), *i.e.*, to $2 \sin^2 \frac{a}{2}$. The electrical work is measured by the product $C^2 R T$, in which C denotes the strength of current, R the resistance of the circuit, and T the time. Hence, for two currents through the same circuit,

$$C_{\prime} = C_{\prime\prime} \frac{\sin \frac{a_{\prime}}{2} \sqrt{T_{\prime\prime}}}{\sin \frac{a_{\prime\prime}}{2} \sqrt{T_{\prime}}}$$

Now, if a known wave ($C_{\prime\prime}$), of such a nature that the ratio between the square roots of the two times may be assumed to be unity, be sent through a galvanometer, and its swing ($a_{\prime\prime}$) be noted, and a like observation be made with the machine to be tested (giving $a_{\prime}$), this formula will furnish an approximate measure of the power of the latter in known electrical units.

This method has been applied to the Breguet apparatus, using for the standard a known condenser charged by a battery of known potential. The latter was 328 volts. Two condensers were employed, the first having a capacity of 1·510 microfarads, and the second 2·344 microfarads. The galvanometer was a fine instrument made by Siemens Brothers, of London, and well suited to this use. The mean results of several measurements, differing but slightly among themselves, were the following:—

The first charge (492 microfarads) deflected the needle 6·0 degrees.

The second charge (768 microfarads) deflected the needle 9·4 degrees.

The Breguet apparatus deflected the needle 17·1 degrees.

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Hence, by the equation given above, the charge given by the Breguet machine was:—

By first standard: $C_{\prime} = 492 \times \frac{0{\cdot}1495}{0{\cdot}0523} = 1{,}407$ microfarads.

By second standard: $C_{\prime} = 768 \times \frac{0{\cdot}1495}{0{\cdot}0816} = 1{,}402$ microfarads.

This method is not rigidly exact, even in theory, but it is the best which has suggested itself to me; and this remarkable coincidence in two independent measurements indicates that these figures may be not without practical utility in comparing apparatus of this class.

(TO BE CONTINUED.)

ON PHOTOMETRY.

BY THOMAS T. P. BRUCE WARREN.

(CONTINUED FROM PAGE 393.)

To the electrical engineer a properly designed photometer may be of much greater utility than the mere measuring of illuminating power; for instance, it may be used for examining lamps, generators, or the carbons themselves, and irregularities in the feeding arrangements of the lamps or the generators can be readily detected.

The Keates lamp, described in the first part of this paper, is used to fix the value of the light given out by a fixed argand burner, giving the light of 16 candles with a 3in. flame. Under ordinary circumstances a variation between 15 to 17 candles may occur. It will generally be sufficient to determine the value of this gas flame once a day, taking care, of course, that the regulated quantity is passing through the meter under the same temperature and pressure.

The flame of the lamp and also the gas burners should be turned up to their proper height and allowed to burn for at least 10 or 20 minutes before testing.

It is important to remember that a standard candle yields only its approximate illuminating value when burning as near as possible its 120 grains per hour; within reasonable limits only is it allowable to make corrections. Exactly the same remarks apply to Keates's lamp; the amount of sperm oil consumed must be very nearly the 200 grains in 20 minutes, and the flame must be altered until it is very near this; for instance, any reading which makes the lamp give a 15 or 17 candle flame must be discarded.

Suppose we had regulated the flame so that in two experiments we consumed 208 grains and 192 grains sperm oil respectively, then by proportion we obtain the value of the flame to be 200 : 208 :: 16 : 16·64 candles,
or 200 : 192 :: 16 : 15·36 „

When once the flame of the lamp has been adjusted, its constancy, as measured by the quantity of oil consumed, is very remarkable. Tables are calculated for the illuminating power of the lamp when consuming the same quantity of oil in the different times, so that by inspection the value of the light in candles can be seen at once.

In practice the candle-power of this flame is determined by the time required in consuming 200 grains sperm oil, which is fixed as giving a 16-candle light. Let an experiment be made in which the 200 grains are burnt in 19min. 37sec., then the light emitted is calculated thus:—

20min. : 19min. 37sec. :: 16 candles : 15·62 candles.

It would obviously be very tedious to watch the lamp to find out when the 200 grains have been consumed; a simple arrangement makes the lamp its own tell-tale when the quantity of oil is burnt.

The lamp properly trimmed and burning is carefully balanced, the final adjustment being made by small lead shot. A two hundred grain weight is placed on the lamp, and as soon as the oil has burnt an equipose is again established. As the arm of the balance regains its horizontality, a small pin falls into a mercury cup, and completes circuit with an electric bell, which at once attracts the attention of the attendant, who at once notes the time or moves a lever which stops the clock, which can then be read off at leisure.

A little practice is necessary to use the lamp successfully, which when acquired is found to involve no trouble or anxiety. The lamp is supported between gimbals on the beam, so that it remains quite horizontal; the flame is kept nearly in the same position, centrally, by the limited range in the deflection of the arm of the balance.

Exactly at the distance of 100 inches from the lamp flame is fixed the argand burner, which is supplied with gas through the test meter, by means of the micrometer cock; the gas is regulated so as to pass at the rate of 5 or 5½ cubic feet per hour. At the rate of 5 cubic feet per hour, with gas of ordinary good quality, burning in a Board of Trade argand burner, we get practically a 16-candle light. The two lights fall on opposite sides of the greased disc in the sighting box, and a reflected image of the two sides of the disc are seen at once. A shadow or dark spot is seen on that side on which is the weaker light, when the sighting box should be cautiously moved until it exactly disappears, leaving no shadow on either side; in this position the lights are exactly balanced. If this were midway between the lights they would be equal to each other.

Suppose the distance between the two lights to be exactly 100in., and that the lights were balanced by moving the sighting box 51in. from the standard lamp, then $51^2 : 49^2$ :: light of lamp : light of gas flame; let the lamp give 16 candles, then

$51^2 : 49^2$ :: 16 : 14·77 candles.

It is better to get several readings than to depend on a single observation, and for this purpose to follow the plan usually adopted in testing gas.

The photometer clock is started by releasing the stop, taking care, of course, that both hands are at zero. The lights are balanced and the reading taken at the end of each minute, so that if the test last for 10 minutes we get 10 observations; the mean of these is taken for the final value of the distances.

If the quantity of gas passing through the metre is 5 cubic feet, and this quantity should be increased or decreased during another experiment, we may, without incurring much error, unless the variation exceed ·3 cubic foot, calculate the value of the gas flame by direct comparison; thus, if 5 cubic feet per hour give 16 candles, then 5·3 cubic feet per hour will give 16·96 candles.

When the photometer is to be used for a whole day or for a long time together, the standardised gas flame can be depended on, and is more convenient than having continually to employ the lamp.

Where great accuracy is not required, the standard argand burner may be used with the test meter, allowing 5 cubic feet to pass per hour, when, with ordinary good gas, the light may be taken to be equal to 16 candles. The length of the gas flame should be three inches; a shield is supplied for cutting off the upper part of the flame. This flame is very convenient for examining small lights, such as from incandescent lamps. There is no difficulty in adjusting these lights to within $\frac{1}{100}$th part of a candle, nor in accurately measuring lights varying from 10 to 100 candle-power against this standard.

For very powerful lights a 500-candle regulating burner with a 6in. flame is used. The value of this light is determined by comparison with the 16-candle flame, on a photometer bar, 150in. long. The adjustment is possible within $\frac{1}{10}$th of a candle without any difficulty.

This larger burner has two photometer bars arranged at right angles to the light, so as to be used simultaneously by two observers; at the end of one bar, which may be 150in. or 200in. long, is fixed, in a suitable box, the arc lamp.

To avoid the glare of the extraneous light from the lamp, the sighting-box slides on a bar fixed in a long shallow tunnel, or shoot, provided with openings which can be opened or closed as required. With this arrangement it is quite easy to test a light of 40,000 or 50,000 candle-power with a closer approximation to the truth than is possible by any other plan.

A little difficulty arises from the difference in colour of the lights to be compared. Discs of coloured glass may be fixed on each side of the greased disc; but with a little practice this can be dispensed with, as the eye can be readily trained to

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detect the shadow on either side of the disc, notwithstanding the difference in colour.

With a 2in. supply pipe to the larger burner the variation in candle-power need not be greater than from 495 to 505 candles. The fluctuations in an arc light can be most accurately measured by two independent observers, one of which carefully balances the two gas flames against each other, whilst the other makes a simultaneous adjustment between the larger burner and the arc light.

It is a curious fact that no embarrassment from differences of colour is felt in adjusting the light of an incandescent lamp against a gas flame, although there is apparently a great similarity between the spectra of the arc and incandescent light.

WATER POWER FOR ELECTRIC LIGHTING PURPOSES.

The Brush Electric Lighting Company of Rochester, New York, have erected a generating station on the west bank of the Genesee River, at what are called the "Lower Falls," in the city of Rochester. It is the intention of the company to utilise the water power of the river to drive turbines, which will be connected by pulleys and belts to a long line of overhead countershafting, from which the dynamos will be driven by belting. The following description of these works is taken, with some abbreviation, from the *Milling World*, an American paper :—

"They (the works) consist of a brick superstructural building or house, 100ft. long by 50ft. wide, and one story high, resting upon and supported by substantial substructural walls and piers of stone and brick, of various heights and forms, and substantially based upon prepared foundations at various levels in the solid rock. The superstructure is spanned across its width at the base of the roof with nine trussed girders, which support the roof and the line shafting with its leading wooden rimmed band wheel, 5ft. diameter by 4ft. 8in. face, and 18 pairs of fast and loose wood-rimmed pulleys, 42in. diameter by 13in. face each, making 360 revolutions per minute, and connecting by 12 inch belts with 18 dynamo machines arranged upon the floor near either side of the building, giving them 756 revolutions per minute, at an expense of 40 horse-power each, making a total of 720 horse-power, supporting 720 lights, equal to 40 lights per machine, or one light per horse-power. The magnitude of the lights is not stated. The fast and loose pulleys which drive the dynamos were furnished by the Taper Sleeve Pulley Works of Erie, Pa., and they are so constructed and arranged that by one single and gradual movement of a double-headed oscillating cam, in connection with a belt shifter, the loose pulley, which hangs on a hollow independent bearing concentric with and surrounding the shaft without contact therewith, is thrown into gear and set in motion, so that as the cam is continuously moved forward through the extent of its parallel arc, which holds the loose pulley in gear, the belt is shifted on to it, when, by a little further movement of the cam, its inclined part at the rear end disengages the clutch, and the loose pulley, together with the belt and the actuated machines, cease moving and remain idle, until the cam is moved in the reverse direction, setting the idler in motion, shifting the belt into working position, and setting the machine in motion, when by the inclined part of the opposite end of the cam from that afore-mentioned the clutch is disengaged and the idler is again at rest, out of contact with any of the running parts.

"It is in contemplation to add nine more electric machines in this same building, to be driven by the same power, should time and circumstance demand it, making twenty-seven in all, producing 1,080 lights and requiring 1,080 horse-power. The power is to be obtained by the use of two Victor turbine water wheels, 20in. in diameter, made by the Stilwell and Bierce Mfg. Co., Dayton, Ohio. This wheel is noted for the extraordinary power developed by it, in proportion to its diameter, while at the same time the percentage of power in proportion to water expended (according to tests made at the Holyoke testing flume) ranks it among the highest and best. Another advantage possessed by this wheel is that its comparatively small diameter for a given power causes it to revolve so rapidly as to make a considerable saving in the cost of shafting and gearing.

"The situation and surroundings of the water wheels and their appurtenances in this case are indeed unique and extraordinary, and indicate a perspicacity of discernment, acuteness of conception, boldness of design, and thoroughness of execution on the part of the projector, that stamps him at once as eminently qualified to place and execute a work like this, environed as it is by great natural obstacles and serious practical difficulties. To make a proper place for the flume or forebay, an open recess or bay was cut into the upper rock bank about 32ft. horizontal depth by 20ft. wide and 46ft. perpendicular depth, down to a level with the bottom of the head race. The bottom of this bay is about 45ft. below the floor of the superstructure, and extends under it about 28ft. From the bottom of this recess at its back side is a shaft about 12ft. square, sunk perpendicularly into the rock to a depth of about 90ft., to a point some four or five feet below the surface of the backwater from the river below the falls, which are nearly 100ft. high. From this shaft a culvert extending about 36ft. in height from the bottom of the shaft is cut through the rock out to the river. Between the top of this opening or doorway, and the bottom of the race and forebay, is about 55ft. vertical thickness of rock.

"On the bottom of said recess in the rock, and partly over the shaft therein, is the flume, containing two U-shaped iron forebays, 7ft. high, opening toward the head race, and from the bottom of which are suspended two iron stand pipes, 76ft. and 10in. long by $42\frac{1}{2}$in. in diameter, their upper ends opening into the forebays to receive water to supply the wheels. At one side of each stand pipe, and connected thereto with a short cylindrical tube, is an iron wheel case, with a draught tube attached to its bottom, and extending some 10ft. downward, and entering the backwater. Besides the support to the stand pipes by their connection with the iron forebays, they and the wheel cases are supported at their bottoms by iron beams. The turbines are placed in the wheel cases, and each one has about 58ft. of steel shafting, $3\frac{1}{8}$in. in diameter, coupled to it and supported by bracket bearings projecting from the stand pipes. Each of said shafts has on it, near its top end, a spur pinion $21\frac{3}{4}$in. in diameter by 17in. face, 17 teeth, 4in. pitch, machine dressed. These gear into a core spur wheel $69\frac{1}{8}$in. in diameter, having 54 wooden cogs, and which is hung on near the bottom of a steel countershaft 6in. in diameter and 60ft. long, on which, near its top end, is a bevel wheel 88in. in diameter, 18in. face, 55 teeth, 5in. pitch, gearing into a core bevel wheel, 99·6in. in diameter, with 56 wooden cogs, 18in. wide.

"This wheel is on a short, horizontal shaft, 6in. in diameter, having on its farther end, beneath the floor of the building, an iron spider carrying a wooden rim band wheel, 10ft. in diameter by 4ft. 8in. face, carrying a rubber belt 4ft. 6in. wide by $\frac{3}{8}$in. thick, which connects with the heretofore described 5ft. leading band wheel on the main line of shafting above, and drives them.

"The turbines operate under 94ft. head of water, including the 10ft. draught tubes, and are estimated to make 582 revolutions per minute, and develop 572 horse-power each, which, combined, equals 1,144 horse-power. The counter upright shaft makes 183·22 revolutions per minute, the counter horizontal shaft, with the 10ft. band wheel, 179·95 revolutions per minute, the main line shaft about 359·9 per minute, and the electro dynamos 755·79 revolutions per minute.

"This work has all been carried out under the direction and immediate supervision of Mr. Joseph Cowles, of Rochester."

S.S. "SILVERTOWN."—This ship, lately employed in the laying of the Central and South American Company's cables, is about to leave London for New Orleans to bring home a cargo of cotton.

NUMBERS OF "THE ELECTRICIAN" OUT OF PRINT.—The following numbers of *The Electrician* are out of print, and cannot be supplied at the office, viz. :—Vol. 1, Nos. 3, 9, 19 ; Vol. 7, Nos. 8, 10, 12 to 18, 20, 21, 24 to 26 ; Vol. 8, 1, 3, 6 to 12, 15 to 26 ; Vol. 9, Nos. 2, 4, 24, 25 ; Vol. 10, No. 13.

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ELECTRICAL UNITS.

The following is the report to the Lords of the Committee of Council on Education by the Committee of Advice with respect to the International Congress for the Determination of Electrical Units to be held at Paris in October, 1883:—

The first International Electrical Exhibition was held in Paris during the months of August, September, and October, 1881, under the auspices of the French Government, who supplemented it by calling together a congress of the leading scientific and practical electricians of all countries. England was represented by the following official delegates:—The Ambassador to France, Sir F. Abel, C.B., F.R.S.; Professor W. G. Adams, F.R.S.; Lieut. R. W. Anstruther, R.E.; Professor W. E. Ayrton, F.R.S.; Professor W. F. Barrett, F.R.S.E.; Sir Charles Bright, M.I.C.E., Commissioner at the International Electrical Exhibition, Paris; Professor Chrystal, F.R.S.; Mr. Latimer Clark, M.I.C.E.; Professor R. B. Clifton, F.R.S.; the Earl of Crawford and Balcarres, F.R.S., Commissioner-General at the International Electrical Exhibition, Paris; Mr. W. Crookes, F.R.S.; Mr. Warren de la Rue, D.C.L., F.R.S.; Professor J. Dewar, F.R.S.; Professor J. D. Everett, F.R.S.; Professor G. Fitzgerald, F.R.S.; Professor G. Carey Foster, F.R.S.; Dr. J. H. Gladstone, F.R.S.; Mr. J. E. H. Gordon; Mr. E. Graves, Engineer-in-Chief, Postal Telegraphs; Dr. J. Hopkinson, F.R.S.; Professor Hughes, F.R.S., Commissioner at the International Electrical Exhibition, Paris; Professor Fleeming Jenkin, F.R.S.; Mr. J. F. Moulton, F.R.S.; Mr. W. H. Preece, F.R.S.; Lord Rayleigh, F.R.S.; Sir W. Siemens, D.C.L., LL.D., F.R.S.; Professor H. Smith, F.R.S.; Mr. Willoughby Smith, Mr. C. E. Spagnoletti, Mr. W. Spottiswoode, D.C.L., LL.D., P.R.S.; Mr. A. Stroh, Professor P. G. Tait, F.R.S.E.; Sir William Thomson, LL.D., F.R.S.; Professor J. Tyndall, D.C.L., LL.D., F.R.S.; Mr. Cromwell Varley, F.R.S.; Mr. C. V. Walker; Lieut.-Col. Webber, R.E., Commissioner at the International Electrical Exhibition, Paris.

Many very important electrical questions were fully discussed, and a universal and international system of units for expressing the results of electrical measurements and observations was determined upon. All parts of the globe being now connected together by a great network of telegraphy, constructed and maintained by every civilised nation, it has become a matter of great commercial, as well as scientific, importance that uniformity should be introduced in modes of working, measuring, and observing throughout the world. The Paris Congress of 1881 has laid the foundation of such a desirable result.

The Congress of 1881 referred certain questions to a second conference, held in the month of October, 1882.

This second conference was divided into three sections (*i.e.*, commissions), the first dealing with "Electrical Units," the second with "Earth Currents and Lightning Protectors," and the third with a question of "A Standard of Light."

Lord Rayleigh, Sir William Thomson, Professor Carey Foster, Professor Fleeming Jenkin, and Dr. Hopkinson were nominated as delegates from England, but Sir William Thomson was the only one present, and he devoted his time principally to the first question.

FIRST COMMISSION.—The Electrical Congress of 1881 adopted, as the fundamental system of units for scientific purposes, a system founded upon the employment of the centimetre, the gramme, and the second, as units of *length*, *mass*, and *time* respectively, and hence known as the C.-G.-S. system of units. The Congress also defined, and adopted a nomenclature for, a a system of electrical standards of such magnitudes as to be, as far as possible, generally convenient for practical use, each practical standard being a decimal multiple or sub-multiple of the corresponding C.-G.-S. unit.* Of these standards, those to which reference is most frequently required are the following, namely:—The ohm, defined as *one thousand million* C.-G.-S. units of *electric resistance*; the volt, defined as *one hundred million* C.-G.-S. units of *electromotive force*; the ampere, defined as *one-tenth* of a C.-G.-S. unit of *electric current*, being the current maintained by an electromotive force of one volt in a conductor of resistance one ohm.

It was further agreed by the Congress that, with a view especially to facility of reproduction, the resistance denoted by the ohm should be stated as being the resistance of a column of mercury at the temperature of melting ice, of one square millimetre in cross-section, and of a length to be ascertained by experiment.

* It is satisfactory to your committee to be able to say that the C.-G.-S. system of units was widely used among English physicists before its adoption by the Electrical Congress in 1881, it having been recommended by a committee of the British Association in 1875; and also that the system of practical standards adopted by the Congress is nearly identical with that previously in use in England and first suggested in a paper by Mr. Latimer Clark and Sir Charles Bright, read before the British Association, in Manchester, in 1861.

Accordingly, the principal question referred to the First Section of the Conference of 1882 was the determination of the length of a column of mercury, of the above-mentioned cross-section and temperature, which had an electrical resistance of one thousand million C.-G.-S. units. In reference to this question, the Conference adopted the following resolutions, namely:—

First Resolution.—"The Conference considers that the determinations hitherto made do not present the necessary degree of concordance for fixing the numerical value of the ohm in terms of a column of mercury.

"It is therefore of opinion that it is necessary to continue investigations in relation to this question."

* * * * * *

Second Resolution.—"The Conference expresses the wish that the French Government should take the necessary measures for placing one or several standard resistances at the disposal of those men of science who are devoting themselves to the investigation of absolute units, in order to facilitate the comparison of results."

Third Resolution.—"The Conference is of opinion that so soon as the results of the various investigations shall be so far accordant that it is possible to guarantee an accuracy of one part in a thousand, it will be proper to accept this degree of approximation for the purpose of fixing the value of the practical standard of resistance."

Fourth Resolution.—"The Conference expresses the wish that the French Government may be pleased to communicate to the Governments represented at the Conference a desire to the effect that each of them, in view of the importance and urgency of arriving at a practical solution, should take the necessary steps to encourage investigations, on the part of its own nation, in relation to the determination of the electrical units."

Upon these resolutions your committee have to observe that experiments made in the Cavendish Laboratory of the University of Cambridge by Lord Rayleigh and other experimenters working in conjunction with him, confirmed by independent experiments by different methods, also made in the Cavendish Laboratory, appear to have attained a greater degree of accuracy than that agreed upon by the Conference as sufficient for present requirements.

Your committee are therefore of opinion that, so far as the determination of the standard of electrical resistance is concerned, it is unnecessary to advise the Government to take any steps in the matter until further researches raise fresh questions relating thereto, as the results obtained at Cambridge seem to possess all the accuracy obtainable at present.

In the second commission, which dealt with earth currents and lightning protectors, various resolutions were carried, which it will be convenient to deal with separately.

The first resolution proposed that the different Governments should organise regular observations upon the behaviour of atmospheric electricity. In reference to this, your committee understand that regular and continuous observations have been made for some years at Greenwich and at Kew, and without further and more detailed recommendations on the part of the Congress as to the special observations they propose, your committee are not in a position to recommend any further steps to be taken by the Government.

The second resolution expressed the wish that a detailed study should be made of the effects of thunderstorms upon telegraphic lines and telephonic lines, and upon buildings connected with wires.

In regard to this your committee have nothing to advise until the Commission have formulated their requirements in more detail; when this has been done, it is understood from the delegates of the Post Office that the fullest consideration will be given to the matter with a view to afford every assistance in the power of that department.

The third resolution dealt with the question of the observation of earth currents. Your committee would observe that continuous records are made by photography at Greenwich of all earth currents occurring upon two telegraphic lines proceeding from the Observatory nearly at right angles to each other; and careful returns are collected from all the principal post offices in the United Kingdom of every unusual and disturbing magnetic storm; and they recommend that a description of the methods employed in this country, which, with notes bearing on the subject is appended, be submitted to the congress with the view to their universal adoption if approved, in order that similar observations may be carried out throughout the world. Your committee at the same time are of opinion that, with a view to meet the wishes of the Congress, some effort might be made to secure observations on Sundays on those telegraphic lines where the staff is necessarily present, but where the number of messages sent is very small.

The fourth resolution suggests the establishment of an inter-

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national network of telegraph wires for the purpose of automatically registering at a central station meteorological changes.

In view of the great expense that would be incurred in establishing a system of wires for automatically recording telemeteorographical observations, your committee concur with the Congress in considering the time has not arrived for adopting that proposal.

The fifth resolution expresses the view that lightning protectors and conductors should everywhere be submitted to a periodical inspection.

This recommendation is at present carried out by the War Office in connection with the buildings under its charge, and the subject has been considered by a Committee of Delegates from the Society of Telegraph Engineers, the Physical and Meteorological Societies, and the Institute of British Architects. There is not, in England, any authority legally competent to discharge the duty as far as the general public is concerned, and it is therefore impossible in England to carry out this proposal in its entirety; but the committee concur in the advisability of adopting that course, where it is found possible to do so.

The sixth resolution implies that the returns of storms and their effects upon buildings and telegraphic lines should be subject to statistical examination.

Your committee consider that the observations necessary for ascertaining the effects of lightning other than on telegraph wires cannot be carried out by the Government, owing to the non-existence of a competent staff throughout the kingdom, and that such observations must of necessity be left to private observers. Your committee recommend, however, that the Meteorological Office be supplied with forms of questions such as may be finally adopted by the congress for distribution to meteorological observers throughout the United Kingdom. The information desired by the Congress would, it is hoped, thus be obtained.

With reference to the effect of lightning on telegraph lines, the delegates of the Post Office who attended the meeting of the committee stated that their department would be able to adopt any form of questions, on which returns could be made, finally proposed by the Congress.

Your committee recommend that the Government should procure such adoption by the Post Office in the United Kingdom, and should also use its influence to cause the same form to be adopted by the Indian and Colonial Administrations, and by the various submarine and other telegraphic and telephonic companies at home and abroad.

Third Commission.—This commission dealt with the establishment of a standard of light by reference to which various electric and other lights could be measured. At the present moment there are two in existence; the one is the French Carcel lamp, and the other is the English standard candle; the former being nearly ten times the latter. No better standard was proposed at the Conference. This question remains in abeyance for further investigation.

Your committee fully recognise the importance of the recommendation to adopt a uniform standard of light.

A committtee appointed by the British Association are now considering the question, and pending their report your committee have at present no recommendations to make.

It will be seen from this report that there are matters of high scientific and practical importance which will be brought before the approaching Congress, and your committee are of opinion that England should be represented, to bring the views above expressed before it, and to assist at its deliberations. The value of the decisions at which the Congress may arrive depends mainly on its international character, and the non-representation of this country would be a serious blow to the authority of its utterances, and perhaps cause the same confusion in electrical science which now exists in others where international accord has not been established. (Signed)

W. G. Adams, R. Y. Armstrong, Maj. R.E.; W. H. M. Christie, G. C. Foster, J. F. Moulton, Rayleigh, C. W. Siemens, G. G. Stokes, W. Thomson.

E. Graves, W. H. Preece, } representing the Post Office.

J. F. D. Donnelly, Col. R.E., W. de W. Abney, Capt. R.E., } representing the Science and Art Department.

8th August, 1883.

Note.—The President of the Royal Society, the late Mr. W. Spottiswoode, was a member of the committee, but his illness and death prevented his taking part in its proceedings.

APPENDIX I.

Instructions Prepared by the Post Office in 1881, as to Observing Earth Currents.

Since during the next two years we may anticipate considerable disturbances from earth currents it is very desirable to possess some authentic records of their *appearance, duration, direction*, and *strength*, to endeavour to arrive at some conclusion as to their origin.

Earth currents are always more or less present, but it is only desired to record the more important, which belong to what are called "Magnetic Storms." Their appearance and duration should always be recorded with reference to *Greenwich mean time* for the purposes of comparison. Their direction should be referred to a positive current, received at the point of observation flowing from W. to E. or from S. to N. Thus a current received in Ireland similar in direction to that produced by attaching the copper pole of a battery to the cable in America is a positive current received at Valentia and every current flowing in this direction is positive. The strength should be recorded in milliamperes.

Knowing the strength of the currents in milliamperes, the compass direction of the circuit, and the electrical resistance of the line in ohms, it is easy to calculate the distribution of potential on the earth's surface.

For example, supposing the earth current received at Valentia were one milliampere and the resistance of the circuit 7,000 ohms:—

$$\frac{x}{7{,}000} = \cdot 001.$$
$$x = 7 \text{ volts.}$$

The strength of any current in milliamperes is easily obtained by reproducing its effect on a galvanometer by one good Daniell cell (1·079 volt) through resistance thus:—

$$\frac{1\cdot 079}{\mathrm{R}} = \frac{\mathrm{C}}{1000} \text{ or } \mathrm{C\,R} = 1079.$$

That is, if the current gives 35° on the galvanometer, and one Daniell cell through 1079 ohms gives the same deflection, then C = 1 milliampere.

Every constant galvanometer should be graduated in milliamperes, or a table should be constructed to give the relative readings.

When earth currents are prevalent it is only necessary to record the observations made on two or three circuits radiating in different directions, but special mention should be made of those which are least affected or *are not affected at all.*

APPENDIX II.

This consists of a list of works on Earth Currents, which we shall give next week.

THE SPANISH NATIONAL CABLES.

Glancing over the telegraphic map of the world, the West Coast of Africa strikes one as almost the only part—putting the extreme northern regions of America and Russia out of the question—where telegraphic communication by submarine cable has not yet been effected. The Spanish National Submarine Telegraph Company, however, is about to supply this deficiency, to a certain extent, and in next year's maps we shall see the familiar black line down as far as Senegal, and, who knows but that once started, in course of time it may extend much farther, perhaps even down to the Cape. But, "sufficient for the day is the evil thereof," and therefore let us turn our attention to what is immediately about to be, rather than waste time in speculating upon what may come to pass in the dim future.

The Spanish National Submarine Telegraph Company has been formed to establish a system of cables between Cadiz, the Canary Islands, and Senegal. The chief station in the Canary Islands will be Santa Cruz de Tenerife, where both the main cables will land, and whence communication will also be established with the three larger islands of the group; these are Gran Canaria, Lanzarote, and La Palma. The cable from La Palma will land at Garachico, a small town on the coast of Tenerife, farthest away from Santa Cruz, and a land line across the island will connect the two.

The distances between the various stations are as follows:— Cadiz to Tenerife 700 miles, Tenerife to Gran Canaria 46 miles Gran Canaria to Lanzerote 96 miles, La Palma to Garachico (Tenerife) 55 miles, and Tenerife to Senegal 805 miles; the total amount of cable to be supplied is about 1,920 nautical miles.

The contractors for the manufacture and laying of the cables are the India Rubber, Gutta Percha, and Telegraph Works Com-

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pany, at which company's works, at Silvertown, the manufacture and shipping of the cables are now being actively proceeded with. The cables are of the usual types, consisting of shore end, intermediate and deep sea, no feature of special novelty having been introduced into their construction. The ships to be employed in the laying of the cables are the "Dacia" and the "International," both of which are now moored off the Silvertown works, taking in cable and stores for the expedition; the cable machinery is being overhauled and strengthened to meet the requirements of the great depth of water in which the cable has to be submerged.

In both ships electricity is employed to a great extent as a substitute for mechanical and other agencies; a system of electric bells as complete as at a grand hotel is fitted up between the cabins, saloon, and pantry, &c., electric telegraphs to the engine room and helm are employed on the bridge, and at the bow and stern for manœuvring the ship during cable operations; the saloons are lighted by incandescent lamps, and arc lights are used on deck for lighting up the whole of the cable machinery when the ship is at work. Both ships have also been fitted with steam steering gear, which will undoubtedly render them more easily manageable when approaching buoys or engaged in other delicate operations incidental to cable-laying; Sir William Thomson's deep-sea sounding gear has been in use since November, 1872, on board the Silvertown Company's ships, and has been modified from time to time, as improvements suggested themselves. On this expedition a modification of Sigsbee's patent detaching sinker is to be used. This ingenious arrangement consists of a thick cylinder of iron, in the centre of which fits a brass tube with a spring bottom; on the sinker striking the bottom of the sea this tube is plunged into the mud or whatever substance the bottom consists of, and retains a sample of it. On strain being applied to haul up, a locking piece, acting on the shackle to which the sounding-wire is attached, sets free a knife, hitherto held securely in position by the action of the locking-piece, which severs the wire connecting the sinker to the tube, and leaves the latter to be hauled up alone. This arrangement reduces to a minimum the risk of losing wire and sinker when hauling up, as owing to the slight weight of the tube there is but little strain on the wire.

The "Dacia" and "International" are expected to leave for the scene of action on Wednesday, the 19th inst. Mr. Robert Gray, the Silvertown Company's well-known engineer-in-chief, will be in charge of the entire expedition, and he will be assisted by Mr. Theophilus Smith, engineer in charge, ss. "International; Mr. E. March Webb, chief electrician; Capt. Hayward of ss. "Dacia," Messrs. H. Benest and J. Rymer Jones, Capt. Tindall of ss. "International," Mr. W. S. Seaton, and a numerous staff of engineers and electricians. The expedition also carries a chemist, Mr. G. Darling, whose duties are to analyse the chemical nature of the samples of bottom recovered in sounding. The engineer to the Spanish National Company is Captain J. E. Hunter, who is assisted by Mr. F. Ormiston.

The Spanish National Company is under contracts with the Spanish Government for the laying of the Cadiz-Tenerife and the Canary Islands connecting sections, and with the French Government for the laying of the Tenerife-Senegal section, and both these Governments have representatives at Silvertown who will also accompany the expedition. These gentleman are, for the French Government, M. Amiot, Ingénieur Chef du Service des Cables Sousmarines, and M. Rambaud, Sous-Ingénieur des Télégraphs, and for the Spanish Government Senores Antonio Augustin and Juan Ravina. The "Dacia" will make two voyages, she will first lay the cable between Cadiz and Tenerife, and then return to Silvertown and take in the cable to connect Tenerife with Senegal, proceeding out again, and laying this in due course. The "International's" share of the work will be the laying of the inter-insular cables, and taking numerous soundings over the proposed line of the cable. Being totally new ground, and the water being deep, a considerable number of soundings will necessarily be taken.

At Cadiz, which offers numerous obstacles in the shape of rocks and shoals to the landing of a submarine cable, a special commission appointed by the Spanish Government, is pursuing investigations as to the selection of a suitable spot for a landing-place; Mr. M. H. Gray, F.G.S., represents the Silvertown Company at the proceedings of this Commission. The Spanish Government have appointed the war frigate "Concepcion" to accompany the ships of the expedition, and render them any assistance in her power. She is now awaiting their arrival at Cadiz.

It is estimated, we understand, that the whole line will be completed before the end of the year; the usual month's guarantee will probably be dispensed with, and the cables will, in that case, be opened to the public a week or so after date of completion provided, of course, that the tests show them to be in perfect condition. It is intended to work the main line by mirror, and the inter-insular cables by double-current Morse instruments of an improved pattern. The whole of the instruments for the working and testing of the line are being supplied from Silvertown, where the instrument department has developed enormously during the last few years, which speaks as much as anything for the quality of the work turned out. Mr. James Jeffery, formerly of the Direct Spanish Telegraph Company, has been appointed local manager of the system, and a large staff of English operators are going out on the "Dacia" and "International," to be landed at the various stations along the line.

In conclusion, we wish all success to the Spanish National Submarine Telegraph Company in their enterprise, and trust that their traffic will be of such magnitude as to encourage them to future extensions of their system. We hope sincerely that the Silvertown Company will meet with the same success that has hitherto attended them in the Mediterranean, Pacific, Mexico, and other parts of the world.

THE SPANISH NATIONAL SUBMARINE TELEGRAPH COMPANY (LIMITED).

The statutory meeting of this Company was held on Monday, at the offices, 106, Cannon-street, E.C., Mr. H. Owen Lewis, J.P., in the chair. Some little difficulty was experienced at first in getting a quorum of shareholders present, and in reply to a question put by the solicitor, Mr. Tyler, the secretary, stated he had done his best to get the shareholders to attend, inasmuch as he had forwarded a circular to each one, but if they did not consider it worth while to attend, of course it was not in his power to enforce their presence. Having waited a few minutes, the solicitor was consulted and stated that it was necessary to have five shareholders present, and in the event of their not attending the meeting would be dissolved.

Another shareholder then having made his appearance, the solicitor said that Mr. Tyler was perfectly qualified to represent the India Rubber, Gutta Percha, and Telegraph Works Company, being a holder of shares, and the meeting was legally constituted.

Mr. Tyler (the secretary) read the notice convening the meeting and the following report of the directors (H. Owen Lewis, Esq., J.P., 1, Lancaster-gate, W.; Count Thadée d'Oksza, 38, Bury-street, St. James's, S.W.; and Francis Anderson, Esq., 35, Gracechurch-street, E.C.) presented to the first meeting of shareholders convened for the 10th inst.: The directors have to report that in May and July last they contracted with the India Rubber, Gutta Percha, and Telegraph Works Company (Limited) for the manufacture and laying of cables (1) to connect Cadiz with Teneriffe, Grand Canary, La Palma, and Lanzarote in the Canary Islands, and (2) Teneriffe with the port of St. Louis in Senegal, measuring respectively about 1,020 and 900 nautical miles. The first-mentioned cables will be laid under a Spanish Government concession of the 3rd of January last. The manufacture is completed, the shipment nearly so; and the contractors' vessels are to leave London on the 18th instant. The line will probably be opened to the public in the first days of November. Thereupon the first instalment of an annual subvention of about £20,000 a year for ten years will become payable to the Company by the Spanish Government. The Senegal cable will be laid under an agreement of the 11th of June last, by which the French Government is to contribute £68,000 towards the cost of the cable. 150 nautical miles are already manufactured; and the contractors expect that the line will be laid and at work by the end of the year. The directors visited the contractors' works and vessels at Silvertown recently, accompanied by Count d'Aunay, Chargé d'Affaires for France, Senor Don del Campillo, Spanish Secretary of Legation, Mr. Graves, Engineer-in-Chief, British Postal Telegraphs, and several officials of the French and Spanish telegraph services. The various processes of the manufacture and shipment of this Company's cables were inspected by the visitors with much interest, and the shareholders may rest assured that the work undertaken by the contractors will be efficiently carried out.

The Chairman moved the adoption of the report, without comment.

The motion was seconded by Mr. Francis Anderson, and carried, and the proceedings then terminated.

THE TELEPHONE COMPANY OF IRELAND (LIMITED).

The half-yearly meeting of this Company was held on Friday, Sept. 7, in the Company's offices, Commercial-buildings, Dublin, Mr. Edmund D. Gray, M.P., presiding.

The Secretary (Mr. J. F. Butterworth) read the notice convening the meeting, and the report of the directors was taken as read.

The Chairman, in moving its adoption, together with the statement of accounts, said that he thought he was justified in congratulating the shareholders on the very prosperous state of affairs disclosed by the report and statement of accounts, which only covered a period of five months. The broken period had been adopted for the purpose of getting into regular half years in future, ending in June and December. A steady increase had taken place in the number of their exchange subscribers, and also in the number of renters of private wires. On the 31st of January last the number of exchange subscribers was 301, which number steadily increased each month until on the 30th of June last, the date at which the report was made up, it had reached 411. Since then the advance had continued, and the number was now about 450. The number of renters of private wires had also increased from 105, at the end of January, to 127 at the end of June, and since the latter date it had further increased to 131 at the present time. The profit and loss account showed that the net profit for the five months, including £329, the proportion of royalties to the United

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Telephone Company charged in the previous half year, and brought forward to credit, amounted to £624. The amount required for the payment of the 6 per cent. dividend was £306, which left a balance of profit of £336. The amount required for the succeeding six months to pay dividend upon the Preference shares was only £375. Thus they had practically carried forward from the five months' revenue sufficient to pay dividend for the succeeding half year, and the earnings therefore roughly represented 12 per cent. instead of 6. The accounts also showed that the rent, which had been paid in advance of the 30th of June, 1883, is £2,360, instead of £1,498, as shown in the last account, which was also very satisfactory. Assets invested amounted to £3,481, and the cash in the National Bank and on hand amounted to £1,421. Since their last meeting they had concluded arrangements with the Corporation for connecting the public offices with the telephone system, and the City Hall, Mansion House, Fire Brigade, and other places were now connected with the central office. Arrangements had also been made for keeping the office open at night, which would be a great advantage, especially on the occasion of fires breaking out in the city. In a short time it was hoped the police authorities would connect the police offices with the system. Nearly all the hospitals had already been connected with the central office. The objectionable conditions sought to be imposed in the new licenses would, it was expected, be modified, if not altogether cleared away, by the negotiations which were being conducted with the Postmaster-General. In course of time they hoped to be able to extend their system to Kingstown, and also to introduce trunk wires. By means of the trunk wires, such as are in use between London and Brighton, and Manchester and Liverpool, Belfast and other important towns in Ireland could be connected with Dublin, and merchants and professional men residing in Dublin could then speak personally to their correspondents or clients residing in Belfast or any other town connected with the system.

Mr. GORDON seconded the motion for the adoption of the report and statement of accounts, and it was passed unanimously.

A resolution declaring a dividend at the rate of 6 per cent. per annum on the amounts paid upon the Preference shares was proposed by the chairman, seconded by Mr. CUMMINS, and adopted.

The business of the ordinary meeting having concluded, an extraordinary meeting was held for the purpose of considering the following resolutions, recommended for adoption by the directors :—

1. Resolved—"That Clauses 2 and 3 of the Articles of Association be varied so that when varied they shall read as follows, viz. :—

2. Resolved—"The original capital of the Company is £250,000, divided into 75,000 Preference shares of £1 each, and 175,000 Ordinary shares of £1 each. The Preference shares shall be issued by the directors to such companies, corporations, and persons, and on such terms as the directors may, in the interest of the Company, think fit, either at a premium or at par, but so that such Preference shares shall not be issued, except with the consent of the United Telephone Company (Limited), signified in writing under their common seal, otherwise than for cash."

3. Resolved—"The holders of the Preference shares shall be entitled to receive out of the profits of the Company a cumulative preferential dividend not exceeding 6 per cent. per annum on the amount for the time being paid up on the Preference shares held by them respectively; and shall have the right to resort to the profits of subsequent years to make up any deficiency in the dividends of preceding years, but shall have no right to any further or other dividend or participation in profits. The Company shall, if resolved at any general meeting of the shareholders, have the right to redeem and extinguish the 6 per cent. Preference shares at any time on payment of a premium of £25 per cent. over the amount at the time paid upon such shares; and shall have the right to redeem and extinguish all other Preference shares at any time on payment of a premium of £10 per cent. over the amount at the time paid or credited as paid upon such shares."

4. Resolved—"That the directors be, and they are hereby authorised to issue 50,000 Preference shares of £1 each, upon the terms of the Articles of Association as varied at this meeting."

5. Resolved—"That the directors be, and they are hereby authorised to exchange all or any portion of the existing Six per Cent. Preference shares for Five per Cent. Preference shares of the new issue, at the rate of 100 of the Six per Cent. Preference shares, with 10s. per share paid, for 120 of the Five per Cent. Preference shares to be credited with 10s. per share paid."

The CHAIRMAN, in moving the adoption of the resolutions, said the Company had found their business exceedingly profitable, and in order to extend it they would, no doubt, require more money in the future. When the Company was first started it was deemed desirable to offer the Preference shareholders good terms, and Preference shares were accordingly offered at 6 per cent., with an assurance that if at any time the Company desired to redeem them, the holders should receive a dividend of 25 per cent. That proposal attracted at once all the capital that was then required. Of the amount then raised, 10s. per share, or £12,500, there was still a considerable sum on hand, but it would not be sufficient to meet the expenditure that would probably have to be incurred in extending the system in the course of a few months. But it was not considered advisable to call up more money on shares for which 6 per cent. would have to be paid, together with a premium of 25 per cent. in the event of the shares being redeemed. The directors therefore asked the Company to convert the six per cent. shares into five per cent. shares; but they did not propose by the conversion to reduce the amount of interest which the six per cent. Preference shareholders received. The proposed change would work out in this way: A man who now holds, say, one hundred shares, upon each of which ten shillings had been paid—his shares bearing interest at the rate of 6 per cent., with 25 per cent. premium, if redeemed—would, if he consented to the proposed arrangement, exchange £100 stock at 6 per cent. for £120 at 5 per cent., upon which he would be credited with £60 as paid, instead of £50. He would then receive 5 per cent. on the £60, which would be equal to 6 per cent. on £50, so that the amount of interest he would receive, assuming no further calls to be made on him, would be precisely similar to the amount he receives now. His liability, however, would be increased from £50 unpaid to £60 unpaid; but he would reap an advantage in the market value of his shares. An application had been made to have the Company placed on the Dublin Stock Exchange, but the application had been refused, probably because the capital of the Company was too small. With an increased capital he (the chairman) was in hopes that if they again applied they would be successful. If they failed to get a place in Dublin they would probably get placed on the Stock Exchange in London. With reference to the proposed change, communications assenting to it had been received from shareholders representing a large number of Preference shares, whilst only comparatively few dissented, and two remained neutral.

Mr. MAYNE, M.P., thought the proposed change was unnecessary, and should not be made. The Preference shareholders had got their shares on what were considered very reasonable terms, and now, when the Company was flourishing, it was sought to change their position in distinct violation of the terms held out in the prospectus of the Company. The change was unnecessary, because at present there did not appear to be any reasonable expectation for an increased outlay. Moreover, it appeared that they had more than they required, and the directors had actually to put out capital at less than 6 per cent., and thus they were incurring a loss. He did not agree with the chairman that the reason they did not get a place on the Dublin Stock Exchange was because their capital was so small. He believed the reason was the disproportion between the capital paid up and the capital subscribed.

The CHAIRMAN, replying, said the development of their business would soon exhaust their capital, and the best time for making the change was when the Company was financially strong. At present money was cheap, and the bank rate low, and they would be in a better position to get what they wanted now than six months hence, when the bank rate would be higher.

The resolutions were then adopted, and the proceedings terminated.

COMPANIES' SHARE LIST.

TELEGRAPHS.

Companies.	Closing Prices Sept. 12.		Business Done Week Ending Sept. 12. Highest.	Lowest.
Anglo American	47¼,	48	47¾	47
Do. Preferred	79½,	80	80	79½
Do. Deferred	17,	17½	17¼	17
Brazil Submarine	11¾,	11⅞	11 13-16	11¾
Cuba	10½,	11	—	—
Do. Preference	17,	18	17¼	—
Direct Spanish	5,	5½	—	—
Do. Preference	15½,	16½	—	—
Direct United States Cable	12½,	12¾	13	12 13-16
Eastern Telegraph	10 11-16,	10 13-16	—	10 13-16
Do. 6 per Cent. Preference	12¾,	13⅛	13 7-16	12 15-16
Do. 5 per Cent. Debentures, 1899	103,	107	—	—
Eastern Extension	11 3-16,	11 5-16	11⅜	11⅛
German Union	9½,	10½	—	—
Globe Telegraph and Trust Company	7 7-16,	7 9-16	7 9-16	7 7-16
Do. Preference	12½,	13	12 15-16	12¾
Great Northern	12¾,	13	12 13-16	—
Indo-European	31,	33	—	—
Mediterranean Extension	1½,	2	—	—
Do. Preference	2,	4	—	—
Reuter's	8½,	9	9	8½
Submarine	220,	230	224	—
West India and Panama	¾,	⅞	⅞	¾
Do. 1st Preference	6,	6½	6½	—
Western Brazilian	5½,	6	—	—
West. Union 7 per Cent. 1st Mortgage	122,	124	—	—
Do. 6 per Cent. Sterling Bonds	100,	103	—	—

TELEPHONES.

Consol. Telephone and Maintenance	5-16,	7-16	—	—
Oriental	5-16,	7-16	—	—
United Telephone	8,	8½	8⅛	7½

ELECTRIC LIGHT.

Anglo-American Brush Lgt. (£7 paid)	2⅛,	2¼	2¼	2⅛
Do. (fully paid)	5¾,	6½	6	—
Hammond Light	1,	1½	1 3-16	1
Eastern Electric (£4 paid)	—,	—	—	—
Swan	1¾,	2	2	1¾
Maxim-Weston	1-16	3-16	3-16	1-16

MISCELLANEOUS.

Telegraph Construction	33½,	33¾	33⅝	33½
India Rubber, Gutta Percha, and Telegraph Works	29½,	30½	30	29½

TRAFFIC RECEIPTS FOR AUGUST, 1883.

Companies.	Aug., 1883.	Aug., 1882.	Incrse.	Decrs.
Anglo-American Telegraph Company	—	—	—	—
Brazilian Submarine Company	—	—	—	—
Cuba Submarine Company	2,275	2,595	—	320
Direct Spanish Telegraph Company	1,514	1,790	—	276
Direct United States Cable Company	—	—	—	—
Eastern Telegraph Company	—	—	—	—
Eastern Extension Telegraph Company	38,126	32,025	6,101	—
Great Northern Telegraph Company	22,900	—	—	—
Submarine Telegraph Company	—	—	—	—
West Coast of America Telegraph Company	—	—	—	—
Western and Brazilian Telegraph Company	—	—	—	—

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NOTES.

BRAZILIAN SUBMARINE TELEGRAPH COMPANY.—The traffic receipts of this company for the week ended September 14, 1883, amounted to £2,914.

LIFE OF THE EDISON LAMP.—It is stated that some Edison lamps in a mill at Philadelphia have lasted on an average 3,886 hours, and are still going.

THE TROPICAL TELEPHONE COMPANY.—At the general meeting of this company, held a few days since at Boston U.S., a dividend of 6 per cent. was declared.

CABLE REPAIRED.—The Eastern Telegraph Company notifies the repair of the Amoy-Shanghai cable, thus restoring telegraph communication *viâ* India with Shanghai and all other places in China.

INTERRUPTION OF TELEGRAPHIC COMMUNICATION.—On Saturday night last, telegraphic communication between Paris and London was interrupted for several hours by a storm affecting the wires.

LIGHTING FROM ACCUMULATORS.—The Willimantic Linen Company's mills, at Willimantic, Connecticut, U.S., have been lighted by means of 365 Swan lamps. The current is supplied by Brush accumulators.

AN ELECTRIC RAILWAY FOR VIENNA.—According to the Vienna correspondent of the *Daily News*, Messrs. Siemens and M. Halske have obtained a concession for preparatory works for electric railways in that city.

ELECTRIC LIGHT FOR A FERRYBOAT.—The Edison Company are about to light the ferryboat "Fanwood," belonging to the Central Railroad Company of New Jersey, with 60 of their A (16 candle) lamps and a Z dynamo.

WEST INDIA AND PANAMA TELEGRAPH COMPANY.—The estimated traffic receipts of this company for the half month ended the 15th September are £2,398, as compared with £1,701 in the corresponding period of 1882.

THE LIGHTING OF DAWLISH.—The Dawlish Local Board are inviting tenders for lighting the streets of this town by oil, gas, or electricity. Tenders are to be sent by the 2nd October to Mr. J. S. Whidborne, solicitor, Dawlish, clerk to the board.

THE ELECTRIC LIGHT FOR NIGHT WORK.—The contractor for the rebuilding of the Alhambra Theatre, Mr. Brass, uses eight Fyfe-Main arc lamps to enable his workmen to proceed with their work at night, in order to complete his contract within the specified time.

DEATH OF A BELGIAN PHYSICIST.—The death is announced of the well-known physicist, M. Plateau, for many years Professor of Physical Science at the University of Ghent. He was chiefly distinguished for his researches on the superficial tension of liquids and in physiological optics

ACCIDENT TO A LINESMAN.—On Saturday last at about ten a.m a fatal accident occurred to a young man named Dally, a linesman. He was at work at the wires on the roof of No. 32, St. Swithin's-lane, E.C., when he slipped on the slates and fell off the roof through a skylight, dashing out his brains.

LIGHTNING IN AMERICA.—The idea that lightning is not so destructive as it used to be in the United States, because the network of railroads and telegraph wires lessens the number of accidents, is met by the record of the summer. Fatal thunderbolts have never been more common.—*Scientific American.*

KILLED BY LIGHTNING.—A Reuter's telegram dated Vienna, Sept. 15, says:—Six women employed in field labour have been killed by lightning at Kolen, in Bohemia, while standing for shelter under a large tree during a thunderstorm. Three other women accompanying them received dangerous injuries.

A LIGHTHOUSE DESTROYED BY LIGHTNING.—The Board of Trade have received through the Foreign Office the following telegram from Her Majesty's Consul at Palermo:—"Marsala Lighthouse completely destroyed by lightning." The Board of Trade understand this to refer to the harbour light on the extremity of the pier at Marsala.

THE FAURE AND PLANTE ACCUMULATORS.—The series of articles by Dr. Gladstone and Mr. Tribe on "The Chemistry of the Faure and Planté accumulators," which appeared originally in *Nature*, and which will be found in the last two volumes of *The Electrician*, has been reprinted by Messrs. Macmillan and Co., of Bedford-street, W.C., in book form.

SPANISH NATIONAL CABLES.—The ships to be employed in the laying of these cables have proceeded as follows:—"The International" left Silvertown for Greenhithe on Monday last, and the "Dacia" on the following day. Both ships, after having adjusted compasses, left Greenhithe for Cadiz on Wednesday, and passed Dover on Thursday morning, all well on board.

ELECTRIC LIGHTING AT KEYHAM.—Her Majesty's steam factory at Keyham is to be lighted during the winter months by Brush lamps. A 16-light Brush dynamo has been fitted up in No. 2 engine house, and is driven by a 3-cylinder Brotherhood engine. The lamps are distributed as follows:—3 in the erecting shop, 2 in the engineer and students' fitting shop, 3 in the smithy, 2 in the coppersmiths' shop, 2 in the fitting shop, and 3 in the turnery.

ELECTRICITY IN PARIS.—The Compagnie Electrique Métropolitaine gave a banquet at the Grand Hotel, Paris, on Tuesday, to inaugurate the lighting of the large dining room by electric lamps. The room was lighted by gas until the first toast, "Electricity," was proposed, when the electric lights were switched on. Subsequently, the omnibus which has been fitted up for electric propulsion, as mentioned in our last week's "Notes," was inspected by the guests.

TELEGRAPH MATERIALS WANTED.—The Great Western Railway Company are inviting tenders for the supply for one year of telegraph wire, instruments, and materials. Samples, &c., can be seen at the office of the storekeeper, Paddington Station, W., and specifications and forms of tender can be had either at this office or that of the storekeeper at Swindon Station. Tenders are to be sent in by the 4th October, addressed to Mr. F. G. Saunders, secretary, Paddington Station.

ELECTRIC LIGHTING IN BALTIMORE.—The Edison Company have just lighted Ford's Opera House, Baltimore, U.S., by their system. A forty horse-power Armington and Sims engine is used, steam being supplied from a Babcock and Wilcox boiler. The dynamo is of the size known as the H, or 400 light machine, and is fitted with an automatic regulator. The stage is lighted by sixty 16 candle lamps as footlights, while four rows of twenty-six lamps each throw light from above down on to the stage.

UNIVERSITY COLLEGE, DUNDEE.—From the syllabus of this college we notice that a special course of lectures will be delivered by Professor Ewing during the winter session on Electrical Engineering. Students who enter for this course must satisfy the professor that they possess a sufficient previous knowledge of electricity. A special laboratory has been fitted up at the college, where students can put into

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practice what they have learnt in the lecture room. A dynamo, gas engine, forge and wood and metal working tools are all to be found there.

A NEW TELEPHONE.—M. Testu, in the employ of the French Posts and Telegraphs Department, is to be credited with a new magnetic telephone. Externally it is shaped like a watch, the glass of which is replaced by an ebonite mouthpiece. The iron plate vibrates before a double magnetic ring, having projections. The continuity of the ring is broken in places. The magnetic polarity alternates from one ring to the other, and each has a bobbin of fine wire, so arranged that the whole of the magnetic field is traversed by the current. The telephone is made by Messrs. Branville and Co.—*L'Electricité*.

THE "OREGON."—On Friday the official trial of the lights and machinery for this the latest addition to the already numerous Atlantic liners was to take place. The Edison system has been used, the engines being specially made by Messrs. Mather and Platt of Salford, Manchester. With the exception of one or two portable oil lamps, no other kind of illumination but that of the Edison system will be used on this ship. The total number of lamps employed is 460 A, or 16 candle-power. We shall have something more to say about this installation in an early number, when we shall give illustrations of the machinery.

ELECTRIC LIGHTING FOR SHOPS.—Some time since, Mr. Peter Jones, draper, of King's-road, Chelsea, commissioned Messrs. R. E. Crompton and Co., of Mansion House-buildings, E.C., to light a portion of his premises with incandescent and arc lamps. These have worked so well that he has recently added to their number. The power is supplied by two 12 horse-power Otto gas engines. An ingenious arrangement, resembling the outside gas lights used for lighting up shop windows, has been introduced here with incandescent lamps, which answers well. The lamps used are, of course, Crompton arc and Swan incandescent.

THE MAKE OF TELEPHONES IN AMERICA.—The net output of telephones by the American Bell Telephone Company for the month ending August 20 was 3,569. This is the lowest of any month this year, and lower than in any month since September, 1881. The output the corresponding month last year was 4,678, and in 1881 was 5,021. The outputs for the first six months of the present and last fiscal year were as follow:—1882: March, 5,192; April, 6,690; May, 7,469; June, 6,362; July, 3,787; August, 4,678—total, 34,178. 1883: March, 4,739; April, 7,342; May, 6,758; June, 7,038; July, 5,846; August, 3,569—total, 35,292.

THE INVENTOR OF THE TELEPHONE.—An American, by the name of James W. McDonough, is now put forward in the United States as the original inventor of the telephone. It is stated that when resident at Chicago so long ago as the 31st December, 1867, he constructed a telephone receiver, consisting of a "combination in an electric circuit of an electromagnet, and a diaphragm supported and arranged in close proximity thereto, whereby sounds thrown upon the line were reproduced accurately as to pitch and quality." But how about Bourseul, who is stated to have invented the telephone in 1854? *Vide The Electrician* for 25th August, 1883, p. 341.

ERECTION OF NEW LINES IN AMERICA.—The *New York Electrical Review* says:—"Contracts to the amount of 1,500,000 dollars for the construction of new lines have been awarded by the Board of Trustees of the Postal Telegraph Company. Lines of two wires each will be put up from New York to Washington, New York to Boston, Buffalo to Pittsburgh, Fostoria, Ohio, to Toledo, and Chicago to St. Louis. Two wires will be added to the wires already strung between New York and Chicago. The lines are to be completed, according to the terms of the contracts, by January 1. The capacity of the copper wires now up between New York and Chicago is equal to twenty iron wires, and will be doubled by the additional two."

BRITISH ASSOCIATION.—The annual meeting of this association was opened at Southport on Wednesday, when the new president, Professor Cayley, delivered an address. We have given this in another column (p. 450), in accordance with our usual custom, though, as might have been expected from its author, the address this year deals chiefly with mathematics. On Thursday the various sections began business, and several papers were read. Some of these we shall hope to put before our readers in next week's issue. We may note here that the Improvement Commissioners of Bournemouth unanimously decided to invite the British Association to hold its meeting there in 1885, or next year, if the proposed visit to Canada should be abandoned. This, however, does not appear to be likely.

DOMESTIC ELECTRIC LIGHTING.—The country house of Mr. Peyton Dashwood, at Godstone, Surrey, has just been partially fitted up with Swan incandescent lamps. These are divided between the dining room, drawing room, boudoir, smoking room, and billiard room, whilst an opal pendant lights the entrance hall and staircase. The lights, brackets, and fittings have been fitted up by Messrs. G. D. Goold and Co., of Northcote-road, Clapham Junction, S.W. The current is supplied by a primary battery patented by this firm, consisting of twenty-three cells, which, we are informed, gives an electromotive force of 43·5 volts. This firm is also fitting up an electric launch, which they intend to drive by means of their battery and an electro-motor.

COAL GETTING.—We notice that a course of special lectures on this subject will be delivered at the Mason Science College, Birmingham, during the ensuing session. The course will extend over two years. Professor Tilden will lecture on the Chemistry of Coal Mining; Professor C. Lapworth on the Geology of Coal Mining; and Mr. John Brown on Theory and Practice in connection with this subject. In the course of his lectures he will deal with the lighting of mines by various means, amongst others electric lights, signalling arrangements (mechanical and electrical), underground haulage, &c. Professor Smith will lecture on Mechanical Engineering, as applied to coal mining. For further details we must refer our readers to the secretary of the college.

LEGAL.—The case of Herz *v.* Van Rysselberghe, which has been before the Courts in Brussels for about a year, is now finally decided. It arose out of a negotiation for the purchase of some of Professor Van Rysselberghe's earlier telephonic patents, which fell through. After M. Van Rysselberghe had signed the contract for the sale of the whole of his patents to Mr. Langdon-Davies, Dr. Herz asserted that he had a prior right to purchase the patents, and brought this action against Van Rysselberghe for specific performance, and also for four millions of francs damages. The Court of Premier Instance gave judgment against Herz, and condemned him to pay the costs. The Court of Appeal also gave judgment against Herz, and condemned him to pay all costs, and also compensation for all damages resulting from the litigation.

THE SWAN AND EDISON COMPANIES.—The following paragraph has been going the round of the daily papers:—"A circular has been issued by the board of the Swan United Electric Light Company (Limited) convening a meeting of the company on Tuesday, October 2 next, for the purpose of

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considering the terms of an agreement about to be entered into with the Edison Electric Light Company (Limited) for the sale to it of the business and property of the Swan Company." This is somewhat misleading. The actual facts of the case are that the Swan and Edison companies have resolved to amalgamate, under the title of the Edison-Swan United Electric Light Company for the working of the Edison and Swan English patents. The foreign patents of both Swan and Edison will, however, remain in the hands of their present owners.

Electric Lighting for Hotels.—The Edison Company of New York have lighted the Sagamore Hotel, Green Island, Lake George, New York State, by their system. The plant consists of one H dynamo with a capacity of 350 A lights, the motive power being supplied by a $9\frac{1}{2} \times 12$ Lawrence engine. The boiler, engine, and dynamo are placed in the engine room, which is situated about 350ft. from the hotel, to which the current is carried by outside conductors. The distribution of the lamps is as follows:—172 lamps in in sleeping rooms (one lamp each), 42 in halls, 12 in billiard room, 3 in bar room, 6 in office, 12 in main entrance, 12 in main parlour, 6 in private parlours, 33 in dining room, 3 in private dining room, 10 in porches, 13 in kitchen and laundry, and 45 in closets, bath room, barber shop, and miscellaneous places; in all, 369 lamps.

The Gramme Patent.—Judge Blatchford has recently decided that the Gramme patent is worthless in America. It appears that the holders of this patent in Austria stopped paying the necessary fees after 1880, and accordingly the patent lapsed. The Arnoux and Hochhausen Electrical Company refused to pay royalties on the Gramme patent in America, on the ground that it was void, according to American law, owing to the expiration of the Austrian patent. This view has been upheld by Judge Blatchford in the New York Southern District Circuit Court. The case will, we believe, be carried into the court above, viz., the United States Supreme Court, by the defendants, the Gramme Company, and if this decision is confirmed the patent will be void in America. The Gramme patent was taken out by Z. T. Gramme and E. K. C. D'Ivernois, in Austria, on the 17th October, 1871, for seventeen years from that date.

Lighting from Batteries.—It may be remembered that Viscount Bury, in a recent article in the *Nineteenth Century*, referred to a primary battery invented by Mr. Ross, C.E. We are informed that this battery is now in use, supplying current to 10 Swan lamps of 20 candle-power, and 26 of 10-candles. The battery is composed of 60 zinc-carbon cells, which are contained in five wooden boxes (4ft. 4in. long, by 14in. wide and 13in. deep outside) sub-divided into rectangular cells, and lined throughout with marine glue, which renders them water tight. It is stated that the full current measured by Ayrton and Perry's meters is from 45 to 50 amperes, and the E.M.F. 110 volts, which figures are reduced to about one-half when the above number of lamps are lighted all together. From tests that have been made it is estimated that with an ammeter in circuit the consumption of zinc is only 12 oz. per hour per electrical h.-p. of 746 volt-amperes. These figures, we may remark, are not our own.

The Telephone in Aberdeen.—We have received a copy of the list of subscribers to the National Telephone Company's Aberdeen Exchange. This is the first time that it has assumed book form, the old list being printed on a card. The opportunity has been taken to make it doubly useful by giving both an alphabetical and a classified list of the subscribers. That is, they are entered both under their names and their trades or professions, the two lists being separate. The advantage of this is obvious. The cover is very neatly got up, and is decidedly ornamental. Prominent on the top and bottom of the cover is the number of the fire brigade station. From the remarks at the beginning of the list we find that the number of exchange connections is 249, and the number of private lines 16, which together represent a length of nearly 150 miles of wire. The longest line is that to Stoneywood Works, which measures 5 miles 654 yards. The exchange is under the able management of Mr. John D. Miller.

Edison System in the House.—Mr. Shaw Lefevre has purchased the Edison plant which has been in use at the House of Commons during the past Session. He intends, owing to the success attending the existing installation, to adopt the light as a permanency, and to considerably extend its use. It will be remembered that the existing plant consists of two 250-light dynamos, and 276 lamps, with all necessary fittings. The new plant will comprise an Armington and Sim's high-speed engine, and two L (250-light) dynamos. The total number of fresh lamps to be employed will be 214, and they will be distributed as follow:—32 10 candle-power pillar lights in the House; 48 pendant lights in division lobbies; 24 table lights in division lobbies; 32 drop lights in retiring rooms; 8 lights in vestibule at back of chair; 12 lights in w.c.'s and lavatories; 12 lights on staircases, &c., leading to retiring rooms; 4 lights in Ministers' rooms; 12 lights in reading room, &c.; and 30 lights in reporters' room. The introduction of the Edison system into this latter room will, no doubt, be hailed with joy by those members of the Press who know what it is to be poisoned by gas.

The City and Guilds Institute.—We observe in the new calendar of the Finsbury Technical College for the session 1883-4, that although the day students will be expected to attend all the courses of instruction included under the department which they enter, still that applications for admission from persons wishing to attend some of the day courses *only* will be considered. And we understand that in the case of *bonâ fide* apprentices who are engaged during a portion of the day time, or others whose professional occupations would render it impossible for them to attend any one complete day course, the permission to omit certain parts of such prescribed course will, on the proper application being made, be freely accorded. We can imagine that this permission will be of especial value to apprentices in the electrical engineering profession, seeing that, while their duties may leave them the mornings free for technical education, the hours of electric lighting will compel them to attend to their professional duties after perhaps three o'clock every afternoon, and will consequently render it impossible for them to remain at a technical college all day. As the college session recommences on the 4th October, application for permission to omit certain courses should, we presume, be made at once. We observe that another privilege is offered to the apprentices of the day courses, viz., that in special cases, to be considered by the committee, the fees may be reduced or remitted altogether.

Electric Lighting at Nottingham.—The members of the Chesterfield and Derbyshire Mining Institute paid a visit to Nottingham on the 11th and 12th inst., and were invited to inspect a domestic installation of the electric light at the house of Mr. G. E. Smith. The dynamo machine used was a De Meritens, and was driven by a small Crossley Otto gas engine, the machine being placed in the garden at the back of the house, and the wires carried in pipes underground to the house. Various kinds of lamps were tried and used, and as some discussion had arisen at the institute about

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the candle-power of lamps, the room was first lighted up by three ten candle-power Woodhouse and Rawson incandescent lamps, and then afterwards with three gas lights, the preference being unanimously given to the three incandescent lamps, the light being softer, whiter, and purer than gas, while the illumination was quite equal, if not superior, to that of the gas lights. Mr. Smith remarked that he estimated the 10 candle-power lamps to be giving about twelve candle-power each, and the gas burners were supposed to be fifteen candle-power. Various sizes of these incandescent lamps were shown, the smallest being one Mr. Smith wore as a scarf pin, and the largest a 100 candle-power lamp. The electrical transmission of power was also shown, the dynamo being used to drive another similar dynamo machine in one of the rooms. This was especially interesting to the members of the institute, as the subject of one of their papers was the transmission of power by electricity.

THE KABATH ACCUMULATOR.—The following table has been given by our contemporary, the *Révue Industrielle*, showing the capacity of the Kabath accumulator at various periods of formation, from 75 hours up to 4,000:—

Number of hours of formation.	Capacity per kilogram of lead.		Weight of lead per horse-power in kilograms.	Energy stored in an accumulator.	
	Kilogrammetres.	Coulombs.		Kilogrammetres.	Horse-power hour.
75	750	5.000	360	15.750	0.058
100	850	5.500	317	17.850	0.065
150	1.000	6.250	270	21.000	0.078
200	1.200	7.350	225	25.200	0.093
300	1.500	9.050	180	31.500	0.116
400	1.750	10.500	154	36.750	0.135
500	2.000	12.000	135	42.000	0.155
600	2.250	13.500	120	47.250	0.175
700	2.500	15.100	105	52.500	0.194
800	2.750	16.400	98	57.750	0.213
900	3.000	17.500	90	63.000	0.233
1.000	3.250	19.000	83	88.250	0.253
1.200	3.750	22.000	72	78.750	0.292
1.400	4.250	25.000	61	89.250	0.330
1.600	4.750	28.000	57	99.750	0.369
1.800	5.250	31.000	51	110.250	0.408
2.000	5.750	34.000	47	120.750	0.447
2.200	6.250	37.000	43	131.250	0.486
2.400	6.750	40.000	40	141.750	0.525
2.600	7.250	43.000	37	152.250	0.564
2.800	7.750	46.000	34,8	162.750	0.603
3.000	8.250	49.000	32,8	172.250	0.642
3.200	8.750	52.000	31	183.750	0.680
3.400	9.250	55.000	29,2	194.250	0.719
3.600	9.750	58.000	27,6	204.750	0.758
3.800	10.250	61.000	26	215.250	0.797
4.000	10.750	64.000	25	225.750	0.836

To convert kilogrammetres into foot-pounds it is necessary to multiply by 7·2; and to convert a kilogram into a pound, multiply by 2·2.

STATICAL ELECTRICITY.—In the *Ann. Chem. Phys.*, 2nd series, Vol. XIX., pp. 325—340, will be found a paper by V. Dvorak, an abstract of which appears in the *Journal* of the Chemical Society for August. The author has made a series of observations on the electric discharge of Leyden batteries consisting of glass plates between thin layers of silver. The form of this charge is dependent not only on the thickness of the silver layer, but also on the intensity of the charge and the distance of the electrodes. The first part of the discharge consists of a large number of sharply-defined ripples, disposed concentrically around the electrode; the second portion consists of thin branches containing only traces of silver; and in the third portion, which is colourless and transparent, silver is wholly absent. If the silver be coated by a layer of some insulating material, as varnish or oil, the ripples are generally absent, and the radiating branches diverge immediately from the electrodes; the colour of the discharge is golden or even brown. If the varnish layer be made too thick the glass plate is frequently shattered by the discharge. On substituting thin layers of graphite for the silver, the discharge took a different form, the ripples were perpendicular to the direction of the discharge. Layers of a mixture of a pulverulent conductor, as finely divided graphite, with stearic acid, give a discharge, the form of which the author compares to a series of needles inserted in the positive poles; olive oil, turpentine, gave similar discharges. The author on examination considers Riess's theory as regards the electric action of flames untenable. According to Riess, two different cases of electrostatic action of flames must be distinguished—first, of substances which only glimmer as carbon; secondly, of inflammable substances, which form a conducting column of hot gas. In the first case, the electrostatic action will arise from a series of solid points, but in the second case from a series of gaseous points. The author quotes experiments to demonstrate that in the first case the action is derived from a series of gaseous points in a heated column. He further proves that the electric repulsions, normal to the surface of a gaseous column, scatter the electrified particles in all directions, so that the whole environment of the flame is filled with electrified particles. This fact offers an explanation of the well-known phenomena of the removal of electricity from an electrified body and the charge of a conductor by means of a flame.

A NEW SEMI-INCANDESCENT LAMP.—M. P. Tibon has shown to the Industrial Science Society of Lyons an electric lamp having the intensity of the voltaic arc and the steadiness of the incandescent lamp. The inventor describes his lamp as follows:—The voltaic arc is usually produced in a gaseous medium (air), constantly heated by it and constantly renewed—a cause of resistance and unsteadiness. If the carbons of a lamp were kept in contact the resistance would be greatly diminished, the arc would no longer be produced, and the light would be absolutely steady but very weak. This decrease in the light is to be attributed to the decrease in the resistance—that is, to the suppression of the arc. We must, therefore, keep the arc to obtain intensity, but we must also fix it by offering it a solid pathway from one carbon to the other instead of abandoning it to the medium of the air. By thus putting the question before me, adds M. Tibon, I was led to cause two carbons to abut on a rod of refractory matter which, becoming a conductor at the point where it is licked by the arc, offers an easy pathway to the latter, from which it will never seek to turn. To put this idea into practice I first of all cut from a small block of chalk a little prism, the section of which is such that one side represents a small rod 5mm. wide, and projecting 2mm. This prism is placed vertically, and the upper parts of two carbons of equal length, and slightly inclined, are made to abut on it so that they remain separated by the small projecting rod. When the two carbons are connected to the two wires from an electrical machine and a current is passed it jumps across between the two points, first of all traversing the small projection; this

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is at once heated to the same temperature as that of the arc itself, and thereby acquires a certain conductivity which, if need be, will maintain the arc, supposing that from one cause or another the current should fail to any extent, thus avoiding any extinction of the light. But this is not the only advantage; the incandescent chalk rod itself gives out a light at least equal to that of the arc. Now, this incandescence will not vary as quickly as the current which feeds the lamps, so that playing the part of a fly-wheel in a steam engine the chalk rod first absorbs the heat of the arc, transforms it into light by its incandescence, and distributes it with the same regularity that a sifter lets flour pass. We should add that these lamps do not cost more than 5fr.—*Les Mondes.*

Submarine Mines and Torpedoes.—In connection with the series of articles on submarine mines now appearing in our columns, the following historical notes will, perhaps, be interesting:—The first attempt to use torpedoes is generally credited to an Italian engineer named Lambelli. At the siege of Antwerp in 1585 he floated boxes filled with gunpowder down the river with the object of destroying a bridge. These boxes were provided with mechanism which was to cause the explosion of the gunpowder on the boxes colliding with the bridge. The Americans, however, claim that David Bushnell, of Connecticut, was the first inventor of the mechanical torpedo. He was born at Saybrook, now called Westbrook, Connecticut, in 1742, and entered Yale College in 1771. During his residence at this college he devoted a great deal of his time to the study of submarine torpedoes and mines. Another American, Robert Fulton by name, took up the subject with great energy at the beginning of the present century. At the time when England was thrown into a ferment by the numerous threats of invasion uttered by Napoleon Buonaparte, Fulton endeavoured to get him to adopt his plan of submarine torpedoes, by means of which he promised "to deliver them and all the world from British oppression." He does not appear to have met with any encouragement from Napoleon, however, and he subsequently betook himself to the United States, where he published a book entitled "Torpedo War, and Submarine Explosions." It is dated New York, 1810, and has the curious motto on its title page, "The liberty of the seas will be the happiness of the earth." His torpedoes were all to be fired by mechanical means, however. The invention of the voltaic battery, and its development was to lead to its adoption for firing submarine mines. In 1829, when but a boy, Colonel Samuel Colt, the inventor of the revolver which bears his name, began experimenting in this direction. He worked hard until 1842, in which year, on the 4th June, he exploded a torpedo in New York Harbour by means of the current from a battery, and on the 4th July following blew up the United States gunboat, "Boxer," opposite Castle Gardens. After this he was taken up by the American Government, and a sum of money, 17,000 dollars, voted him, to enable him to continue his experiments. On the 20th August, 1842, he destroyed a schooner on the Potomac river, when five miles away from her, and on the 18th of October, 1842, he blew up the brig "Volta," in New York Harbour. It is generally conceded that Colonel Colt was the first to utilise electricity for firing mines. The following extract from "Torpedoes and Torpedo Warfare," by C. W. Sleeman (Griffin and Co., Portsmouth, 1880), will be read with interest:—"From Colonel Colt's private papers and memoranda, it appears that he claimed to possess a further secret, which died with him; but that his invention consisted principally in the arrangement of groups of torpedoes connected by insulated wires with each other and with the galvanic battery, and that one of his projects was to compel a vessel to tell her proximity by telegraph as she touched certain parts of his apparatus, or, by a method since adopted by the Austrians, the vessel's contact caused the circuit to close, and thus insured the explosion at the proper instant. To Colonel Colt certainly is due the credit of being the first to conceive of the project of igniting deposits of powder, placed in harbours for their defence, by means of galvanic electricity; and the cable employed by him in this connection was the first submarine cable ever invented for conducting the electric fluid, only differing from the most approved forms of present telegraphic submarine cables in the substitution of asphaltum and beeswax instead of gutta percha, then unknown."

Magnetic Survey of Missouri.—In a paper read at the meeting of the American Association for the Advancement of Science, held at Minneapolis, on the 15th August last, Mr. F. E. Nipher said:—"In the spring of 1878 a survey of Missouri was begun, which was expected to determine all points in regard to terrestrial magnetism; 160 points have been covered. The work was undertaken under private auspices, most of the money tendered unasked, and the work has been carried on successfully until the present time. The first three years were spent in making a preliminary survey. In the early part of the survey we laboured under great difficulties, because I supposed that the lines of equal value, laid down upon the observations given in the coast survey charts, were substantially correct; so that time was frequently lost in repeating values at stations left behind, in order to be certain that no error had been committed. But when we settled down to the conclusion that we really knew nothing about the matter, we had very much less trouble. At first intensity determinations were made at each station, but in later years, since the magnets have proved so satisfactory, the plan was adopted of making absolute determinations only at regular intervals during the summer. The temperature corrections for the magnet were made twice—once in 1878 and once two years ago—and they agreed very closely with each other. The dip circle was a large one, such as was formerly much used, and which was found to be an excellent instrument, though rather clumsy to carry. The charts which have been prepared show what the results were. In a former communication to the association at Cincinnati I suggested an explanation of the peculiar flexures of the isogonic lines, as being due to earth currents which seemed to be deflected by the moist river valleys. The map upon which that hypothesis was based represented observations taken over the entire state. By redetermination we have found that those observations were all correct, but more detailed work shows that this explanation is not admissible. There is no explanation of the fact that contour has anything to do with the deviation of the needle from the normal values. Similar flexures are also seen in the lines of equal inclination and the lines of intensity. One and perhaps two years will be required to accomplish the work properly. There is nothing new in the subject, except the rather unexpected flexures which we found in these lines. It shows very clearly that the isogonic lines which are published for the use of surveyors are of no earthly use. Work ought to be done in a detailed way over the whole country, and I hope we shall some time be able to combine with these determinations a series of magnetic values at ten or twelve different stations in the State of Missouri, and also simultaneous determinations of earth currents upon lines making angles with each other at the different stations. Similar variations would probably be found in the States of Illinois and Iowa."

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POTENTIAL, CURRENT, AND RESISTANCE.—V.

BY JOHN T. SPRAGUE.

(CONCLUDED FROM PAGE 417.)

48. One remarkable consequence of the ideas of electrical action worked out in these papers is that we can entirely eliminate the conceptions of electromotive force and of resistance, replacing them in calculation by "energy at disposal" and "facility for its transformation;" we can then arrive at the results of Ohm's formulæ by a calculation based upon unit values of these two elements.

49. For the convenience of comparing processes of thought, let us make the ampere current the starting point, the term in which we desire to express results.

(*a*) Let C be the current per second of which the ampere is the unit, represented by ·00001022 gramme of hydrogen, or the equivalent of any other substance.

(*b*) Let J be the unit quantity of energy, corresponding to that of 1 ampere current during 1 second, under such conditions as we constitute the unit of "facility of transformation of energy;" actually we make J = the joulad = calory ·24, or more exactly log. $\bar{1}$·3767503.

(*c*) Let A represent, as in Section 22, the unit conductor just referred to, which permits J to be transformed from potential to kinetic energy while generating 1 ampere current; this property is, of course, dependent upon some specific constitution of the matter in which the transformation is effected, with which we have not now to concern ourselves.

(*d*) A and J are, therefore, so connected with C, that any two will of necessity define the third; and C and J being defined, A may be fixed by arranging a circuit in which J produces C, and this may be defined as the unit conductor. As this converts the whole of J into heat, or kinetic energy, a similar conversion will occur in a succession of such circuits through which C passes, and each must require J of energy to be supplied to it; failing this, a smaller quantity of energy will be distributed over each unit portion, and a smaller current will traverse the series.

(*e*) The value A will increase in the ratio of the number of such unit conductors equally open to the energy; that is, parallel circuits, and diminish in the ratio of the number added to the circuit; that is, in series. Or, if we regard the consumption of energy as a resistance, the *true resistance* of Section 6, then A will be *inversely* as the number of units of energy necessary to maintain unit C.

(*f*) It is obvious that we have here values corresponding to those of the volt and ohm, and of necessity so, because we have started from the ampere with the intention of making the two sets of ideas run parallel with each other, so as to illustrate the natural truths embodied in them, and evidently the actual va'ues must be the same, whatever theoretical views we may connect to them.

(*g*) Let P be the potential energy of the gramme equivalent (expressed, as it commonly is, in calories) of any chemical reaction, generating electric current, multiplied by the ampere equivalent of the substance. For example, we have, as in Section 37,

Calories per equivalent, hydrogen		34462	·4·5373405
Ampere equivalent	„	·00001022	$\bar{5}$·0095453
P = potential energy of reaction			$\bar{1}$·5468858

(*h*) This gives us the potential energy which we have available for charging upon the molecular chain in which it is to be rendered kinetic. This value, if divided by J, gives us the expression of E.M.F. in volts, as in Sections 37 and 39. J is, in fact, a unit expression or value of P, which needs to be reduced to this unit in order to give results in amperes of current; but J is not a volt of E.M.F. when so employed, but a form of the "equivolt," Section 40, reduced to the ampere equivalent, instead of the gramme equivalent of Section 39, or the grain equivalent of Section 40; that is, it expresses energy itself, not the E.M.F. to which the energy is equivalent when the existence of E.M.F. is assumed.

(*i*) Now, J × A = C. That is to say, potential energy × by the capacity for transformation = the rate of conversion in the molecular chain in which it occurs, such conversion being effected by a molecular change or rotation, which we can call a quantity, and measure as current.

This mode of considering the subject is exactly parallel with that of Section 22, where E × A = C in accordance with the usual system of E.M.F. and conduction.

50. Of course this system is not proposed as having any importance as to practical use, but it shows that the received formulæ, however useful, are purely artificial; it shows that the conceptions of electromotive force and resistance are mere expressions, not for facts or actual existences, but for *conditions*; and it altogether disposes of the fictitious "contact *force*" by showing that pure energy accounts for all the phenomena which this force was invented to explain.

51. From all these considerations we learn that *electricity is a process of degradation of energy.* It is always an accompaniment or consequence of potential energy becoming kinetic, of latent force or energy becoming free, and usually taking the form of heat. Even where the object of the processes is the storing kinetic energy, as for instance in electrolysis, or charging secondary batteries, yet on the whole, less energy remains in the kinetic state as a result than was so existent before the action. No electric action ever occurs without free heat appearing somewhere as its necessary result; this free heat, which is dissipated, or work equivalent to such free heat, is the measure of the force or agency which develops electric action.

52. Electric generation is always consequent upon either,

1. The mutual action of two classes of molecules which have either,

(*a*) A different capacity or conductivity for heat, as in frictional and thermo-electricity.

(*b*) A tendency to chemical interchange, accompanied with a lowering of the total intrinsic energies.

2. The passing of conducting bodies, in which current can be produced, across a field of force (which involves a definite molecular arrangement of the substances in which it exists) in which the molecules are compelled to undergo a rotation during the transit in order to adapt themselves to the polar construction of each part of the field which they successively occupy. This is the origin of magneto-electricity and the electric phenomena of crystals.

53. In *all* cases energy is charged upon and transmitted along definite molecular chains to some point at which it becomes free. It is this energy, derived from chemical action, combustion of fuel, falling water or wind, which sets up the electric action, and the nature of that action depends upon the quantity of energy passing from the potential to the kinetic state, and the character of the molecular changes in which the transformation is effected in such manner that

Electric quantity measures the number of molecular impulses produced in the conducting chain.

Electromotive force, or potential, measures the stress in the individual chain, and under which these impulses are produced.

54. We see thus the nature of the resemblances and the differences between heat and electricity. Both are molecular motions distributing energy.

Heat is a general distribution, motion transmitted to all surrounding molecules.

Electricity is a specific motion, limited to and transmitted along definite chains of molecules, forming closed circuits, and a polar system.

54. The cause which sets up the conditions may be located at one point, or distributed over various parts of the chain, in which latter case the stress on the chain is equal to the sum of the energies, but the "quantity" remains that of the single chain. Therefore the same "quantity of energy" will develop different so-called "quantities of electricity," according to the nature of the molecular chain to which it is applied, but the time occupied in the development will also vary with the conditions, and the variations in these relations are identical in nature and in proportions with those which occur in the ordinary mechanical applications of energy to doing work.

55. In concluding these papers, in which I have endeavoured to give a distinct meaning to various terms which are

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but vaguely apprehended by many who use them, I may express the hope that they may satisfy many who are discontented with the commonly taught doctrines of electricity, and show them that these doctrines do really contain within themselves much more than their teachers usually explain. Thus, Mr. Theophilus Varley, who wrote an interesting letter on "Electricity, What is it?" p. 301, may find that many of his ideas are developed both in these papers and in my "Electricity," while the variety of units to which he objects arises from giving a different name to different aspects of the same conception. It is more convenient to separate the ideas of the coulomb, ampere, and farad than to attach explanatory words to one unit, that is, it is more convenient to have the unit of current the ampere, than to speak of the coulomb per second, and the same applies to the joulad and the watt as expressions for the energy or power corresponding to an ampere linked to a volt.

ON THE SIZE OF CONDUCTORS FOR THE DISTRIBUTION OF ELECTRIC ENERGY.*

BY THOMAS GRAY, B.SC., F.R.S.E.

The principal questions which have to be considered in the determination of the proper size of conductors for the distribution of electric energy are:—

(1) *Economy*,† or the amount of metal which must be put into the conductor in order that the sum of the annual cost for interest on capital, for depreciation, and for energy lost in consequence of heat generated in the conductor by the current may be a minimum.

(2) *Safety*, or the amount of metal necessary to prevent excessive heating.

(3) *Regulation*, or the amount of metal required to prevent too great a variation of potential along the leads.

In the consideration of the question of economy, let I be the fraction of the original cost of the conductors to be allowed annually for interest and depreciation combined, let P be the price per unit volume of the conductor, A its sectional area, and l its length. Then the cost per annum of possessing the conductor is

$$\mathrm{I P A} l.$$

Again, if E be taken as the cost of one erg of electric energy, c the current flowing in the conductor at any time t, and S the specific resistance of the material, the energy lost in heat will cost per annum

$$\mathrm{E S}\frac{l}{\mathrm{A}}\int_0^{\mathrm{T}} c^2\, dt,$$

where T is the number of seconds in a year. In most cases c will be a complicated and somewhat uncertain function of t, in consequence of which it may only be possible to form a rough estimate of the value of the integral. Let C be such a quantity that

$$\mathrm{E S}\frac{l}{\mathrm{A}}\int_0^{\mathrm{T}} c^2\, dt = \mathrm{E C^2 S}\frac{l}{\mathrm{A}}\mathrm{T},$$

and we get for the total annual expenditure due to the conductors the expression

$$\mathrm{I P A} l + \mathrm{E C^2 S}\frac{l}{\mathrm{A}}\mathrm{T}. \quad . \quad . \quad . \quad . \quad (a)$$

The expression (a) has the minimum value when

$$\mathrm{A} = \mathrm{C}\sqrt{\frac{\mathrm{E S T}}{\mathrm{I P}}} = \mathrm{C}\sqrt{\frac{\mathrm{E S}}{i \mathrm{P}}}, \quad . \quad . \quad . \quad (1)$$

where i is the fraction of the original cost to be allowed per second for interest and depreciation.

Equation (1) shows that, from a purely economical point of view, the section of the conductor should be directly proportional to the quantity C, which, when the current is continuous and of constant value, is the current-strength in C.-G.-S. units, but which, when the current is variable, has such a value that the heat which would be generated by a continuous and constant current of that value is equal to the actual heat generated. The section should also be directly proportional to the square root of the product of the cost of energy and the specific resistance of the conductor, and inversely proportional to the square root of the product of the first cost and the rate of interest and depreciation to be allowed, while it is independent of the length of the circuit.

Equation (1) gives in all cases an inferior limit below which it is not advisable to reduce the section of the conductor. It should be noticed, however, that the investigation proceeds on the assumption that the whole of the energy wasted is due to the generation of heat in the main conductor by the current. This assumption may be, in many cases, inadmissible, owing to the varying E.M.F. at which the electricity would be supplied and the consequent loss of energy in regulation; and in such cases the economy problem assumes different forms depending on the conditions imposed.

Practical Example.

Let us suppose, for the sake of illustration, that the cost of one erg, or E, is, reckoned in pounds sterling,

$$\mathrm{E} = \frac{1}{10^9\mathrm{T}},$$

that the conductors are of copper having a specific resistance

$$\mathrm{S} = 1700,$$

that the price of copper conductors manufactured is

$$\mathrm{P} = \frac{1}{1200},$$

and that the rate of interest and depreciation is

$$\mathrm{I} = 7{\cdot}5 \text{ per cent.}$$

Then we have

$$\mathrm{A} = \mathrm{C}\sqrt{\frac{1700 \times 1200 \times \mathrm{T}}{7{\cdot}5 \times 10^7 \times \mathrm{T}}}$$

$$. \quad . \quad . \quad . \quad . \quad . \quad . \quad = \frac{\mathrm{C}}{6},$$

or, when C is reckoned in amperes,

$$\mathrm{A} = \frac{\mathrm{C}}{60}. \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (2)$$

This gives 60 amperes per square centimetre of section as the proper relation between the current and the section of the conductor. It must be remembered, however, that this calculation is based on the assumption of bare copper conductors and on a particular estimate of the cost of energy, both of which may have to be greatly modified in particular cases.

If, for example, covered cable, costing, say, five times as much as bare copper, be used, the proper ratio of the section of the conductor to the current would be

$$\frac{\mathrm{A}}{\mathrm{C}} = \frac{1}{60\sqrt{5}} = \frac{1}{134}; \quad . \quad . \quad . \quad . \quad . \quad . \quad (3)$$

or, for every 134 amperes of current there should be one square centimetre of section in the copper conductor.

Safety.

We have next to consider whether the size of the conductors given by the above considerations will be sufficient for safety. The answer to this question depends on the rise of temperature which will be produced by the greatest current which is to be sent through the conductor. (This greatest current must not be confounded with C in equation (1), as the strength of the current may occasionally greatly exceed that which it is proper to use according to that equation.) It is easy to calculate to a considerable degree of approximation the rise of temperature which will be produced in a conductor by an electric current when we know the specific resistance of the material, the emissivity of the surface, and, in the case of covered wire, the thermal conductivity of the covering.

If we assume the rate of cooling for any conductor per unit

* From the *Philosophical Magazine* for September.

† This problem for the case of a constant current flowing during the same portion of each day, has already been treated by Sir William Thomson, in a paper communicated to the British Association at the York Meeting, 1881. *Vide Electrician* Vol. VII., p. 295.

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length per unit difference of temperature to be r, we have for the total rise of temperature t the equation

$$\frac{c^2 S(1+\alpha t)}{A} = t r, \text{ or } t = \frac{c^2 S}{rA - c^2 S\alpha}, \quad . \quad . \quad (4)$$

where α is the coefficient of change of specific resistance with temperature. That is to say, for any conductor the rise of temperature depends directly on the square of the current and on the specific resistance of the material, and, if we neglect the variation of specific resistance with temperature, inversely on the rate of cooling and the section of the conductor.

If we assume 50°C. as the maximum rise of temperature, we have for the section of the conductor,

$$A = \frac{c^2 S(1+50\alpha)}{50\, r}.$$

For bare copper rod we may take r as being very nearly $\frac{J}{5000}$ multiplied by the number of units of radiating surface in the unit length, or

$$r = \frac{\pi d J}{5000},$$

where d is the diameter of the rod (supposed cylindric), and J Joule's mechanical equivalent of heat, which is, approximately, $4{\cdot}2 \times 10^7$ in C.-G.-S. units. Hence, by substitution,

$$r = \frac{3{\cdot}14 \times 4{\cdot}2 \times 10^7}{5000} d = 2{\cdot}64 \times 10^4 d. \quad . \quad . \quad (5)$$

Now, as S is 1,700 and α nearly ·0039, we have

$$A = c^2 \frac{2030}{13{\cdot}2 \times 10^5 d} = \frac{1{\cdot}54}{10^3} \times \frac{c^2}{d}.$$

It must be remembered that c is here taken in C.-G.-S. units; and hence, putting for A $\frac{\pi d^2}{4}$, and taking c in amperes and reducing, we get

$$c = \frac{10^3}{4{\cdot}42} d^{\frac{3}{2}}. \quad . \quad . \quad . \quad . \quad . \quad . \quad (6)$$

Now the value of C found from equation (2) is for bare copper 60 amperes per square centimetre. Let us assume that the maximum value of c will be 100 amperes per square centimetre, and we have to find for what value of d or c we have

$$A = \frac{\pi d^2}{4} = \frac{c}{100}. \quad . \quad . \quad . \quad . \quad . \quad (7)$$

From (6) and (7) we get at once

$$d^{\frac{1}{2}} = \frac{4 \times 10^3}{\pi \times 442},$$

or $$d \doteq 8{\cdot}5.$$

From this we see that the conductor will only rise 50°C. in temperature when the current is of such strength as to require a conductor eight and a-half centimetres in diameter. The question of safety, then, may, at least in the case of uncovered copper rod, be left out of consideration when the current is less than 5,000 amperes.

Next take the case of a conductor of circular section covered with a substance whose thermal conductivity is k. In this case r depends both on the rate of cooling from the surface, or the emissivity, and on the conductivity k.

Let e = emissivity of the surface.

T = difference of temperature between the two surfaces of the covering.

T′ = the difference of temperature between the external surface of the covering and the surrounding atmosphere.

r_2 = the external diameter of the covering.

q = the quantity of heat conducted through the covering per unit of time.

Then, since for constant temperature we must have the quantity conducted through the covering equal to the quantity radiated from the surface, we have

$$2\pi r_2 e T' = q. \quad . \quad . \quad . \quad . \quad . \quad . \quad (8)$$

But

$$q = -2\pi k x \frac{dt}{dx}, \quad . \quad . \quad . \quad . \quad . \quad (9)$$

where x is the radius of any cylindric surface in the covering coaxial with the conductor. Hence

$$2\pi r_2 e T' = -2\pi k x \frac{dt}{dx},$$

or

$$\frac{dt}{dx} = -\frac{e}{k}\frac{r_2}{x} T'. \quad . \quad . \quad . \quad . \quad . \quad (10)$$

But the total difference f temperature between the two sides of the covering is

$$T = -\int_{r_1}^{r_2} \frac{dt}{dx} dx$$
$$= T' r_2 \frac{e}{k} \int_{r_1}^{r_2} \frac{dx}{x}$$
$$= \frac{e}{k} T' r_2 \log_e \frac{r_2}{r_1}. \quad . \quad . \quad . \quad . \quad (11)$$

Now, by the conditions of the question,

$$T + T' = 50;$$

that is to say,

$$T' \left\{ 1 + \frac{e}{k} r_2 \log_e \frac{r_2}{r_1} \right\} = 50. \quad . \quad . \quad (12)$$

Assuming, what are probably not far from the true values for gutta-percha, e and k to be $\frac{1}{4000}$ and $\frac{1}{2000}$ respectively, we get

$$T' = \frac{50}{1 + \frac{1}{2} r_2 \log_e \frac{r_2}{r_1}}. \quad . \quad . \quad . \quad . \quad . \quad (13)$$

Again, since the amount of heat generated by the current must be equal to the quantity radiated from the surface of the covering,

$$\frac{c^2 S(1+50\alpha)}{AJ} = \frac{2\pi r_2}{4000} t_1;$$

by equation (13),

$$= \frac{2\pi r_2}{4000} \times \frac{50}{1 + \frac{1}{2} r_2 \log_e \frac{r_2}{r_1}}$$

$$= \frac{\pi r_2}{40 \left\{ 1 + 1{\cdot}15 r_2 \log_{10} \frac{r_2}{r_1} \right\}}. \quad . \quad . \quad (14)$$

Take, for example, $r_1 = 1$ and $r_2 = 1{\cdot}4$. Then

$$c^2 \frac{2030}{\pi \times 4{\cdot}2 \times 10^7} = \frac{\pi \times 1{\cdot}4}{40\{1 + 1{\cdot}15 \times 1{\cdot}4 \log 1{\cdot}4\}};$$

$$\therefore c = \pi \sqrt{\frac{1{\cdot}4 \times 4{\cdot}2 \times 10^7}{40 \times 2030\{1 + 1{\cdot}15 \times 1{\cdot}4 \log 1{\cdot}4\}}}$$

$$= \pi \times 24{\cdot}2.$$

That is to say, a rod 1 centimetre in radius and covered with gutta percha to a thickness of 4 millimetres requires a current of 242 amperes per square centimetre to raise its temperature 50°C.

If we suppose $r_1 = 1$ and $r_2 = 5$, we find $c = \pi \times 22{\cdot}7$, or a current of 227 amperes would heat the conductor 50°C. Increased thickness, therefore, in the covering does not greatly alter the capacity of the conductor.

Regulation.

It is of great importance, especially in electric-lighting circuits, that the E.M.F. at which the electricity is supplied should be nearly constant. Various methods may be resorted to for the purpose of securing this; but we do not propose to go further into the matter at present than to investigate what

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the maximum difference of E.M.F. will be between different parts of the systems when the conductors are of the size which we should be inclined, from economical considerations, to adopt.

Let the E.M.F. between the conductors at any point P of the system (say at the poles of the generator) be kept at the constant value e volts. Then, if the current in amperes per square centimetre of the section of the conductor, be C, we have

$$C = 10^9 \frac{x}{S},$$

where x is the E.M.F. in volts per unit length along the conductor. Now x is half the variation of E.M.F. per unit length along the system; and hence, if v be this variation,

$$v = \frac{2}{10^9} C S. \quad . \quad . \quad . \quad . \quad . \quad (15)$$

Let us assume, as before, that the maximum value of c is 100, and we get

$$v = \frac{2 \times 100 \times 1700}{10^9} = \frac{34}{10^5}. \quad . \quad . \quad (16)$$

If we assume that the greatest percentage variation of E.M.F. allowable is p, we get for the distance d of the furthest point of the system from the point P,

$$d = \frac{1000}{34} e p$$

$$\doteq 30 e p. \quad . \quad . \quad . \quad . \quad . \quad (17)$$

When $p = 5$, which produces a very inconvenient variation in the illuminating power of the incandescent lamps at present made, we get with

$e = 50$, $d = 75$ metres,
$e = 100$, $d = 150$ „
$e = 200$, $d = 300$ „

and so on.

SUBMARINE MINES.

(CONTINUED FROM PAGE 427.)

The Jürgensen Machine.—This apparatus (Fig. 2) is identical with the Marcus machine (soon to be described) in electrical principles, although differing widely in mechanical details. It was adopted in the Danish naval service for boat use, being compact and portable, but it is rather deficient in power.

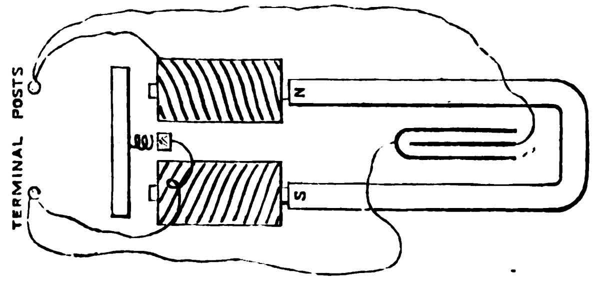

FIG. 2.—The Jürgensen Machine.

The case is of wood, 12in. by 6in. by 4in. in size, and the whole weight is 16lb. It contains a horizontal permanent magnet, of which the poles, prolonged by soft iron, form the cores of two coils of fine copper wire having a total resistance of 1,170 ohms. The two free ends of these coils are attached to terminal posts outside the case, which are also connected with the opposite coatings of a small condenser having a capacity of 0·0024 microfarads. A shunt circuit also connects the terminals, consisting in part of a spring moving with the armature, which, when the current induced by the magnetic wave traversing the cores of the coils is at its maximum, breaks the shunt, and discharges the extra spark thus induced, multiplied by the condenser, through the fuse.

The mechanical device for removing the armature is the following:—In its normal condition this armature is separated from the core ends, being attached to a horizontal rod extending between the bars of the magnet. A strong spiral spring holds the armature away from the poles. A keeper, to preserve the strength of the magnet, is in contact with the under part of the poles beyond the coils. To set the apparatus for firing, the end of this horizontal rod, which projects beyond the case, is pressed in until the armature touches the cores, when the rod is caught and held by a latch-spring. This motion also removes the keeper by a neat device. On touching the trigger, the latch-spring is released, and the coiled spring jerks off the armature, thus inducing a magnetic wave through the cores which generates the desired current in the coils.

Like the rest of its class, this instrument requires medium tension fuses, and they should be coupled in series if more than one be used. To determine the strength of current which the Jürgensen machine is capable of developing, measurements were made by the method described for the Breguet machine. While the two condensers charged to a potential of 328 volts gave swings of 6 and 9·4 degrees respectively, this instrument gave 36 degrees. Hence, by the before-mentioned equation (see ante p. 426),

$$C_{,} = 492 \times \frac{0{\cdot}3090}{0{\cdot}0528} = 2{,}906 \text{ microfarads.}$$

$$C_{,} = 768 \times \frac{0{\cdot}3090}{0{\cdot}0819} = 2{,}897 \text{ microfarads.}$$

Hence, the instantaneous current from this apparatus is stronger than that of the Breguet machine in the ratio $\frac{2902}{1404} = 2{\cdot}1$ times. This result is confirmed by four direct comparisons made in 1875 and 1880, upon the same galvanometer, with its swing regulated by a magnet placed near the needle. Thus,

Breguet, 4·0°;	Jürgensen, 9·5°;	ratio by equation,	2·3 times
„ 6·0°;	„ 14·5°;	„ „	2·2 „
„ 8·2°;	„ 18·4°;	„ „	2·0 „
„ 16·3°;	„ 35·3°;	„ „	2·1 „
		Mean ratio,	2·15 „

The Marcus Machine.—This instrument, suggested by Baron von Ebner, of the Austrian Engineers, in 1862, is very compact and ingenious, and is said to be adopted in the land service of Austria and Prussia, and in the French naval torpedo service. It is 5in. by 4in. by 13in. in size, and weighs 20lb. *Vide* Fig. 3.

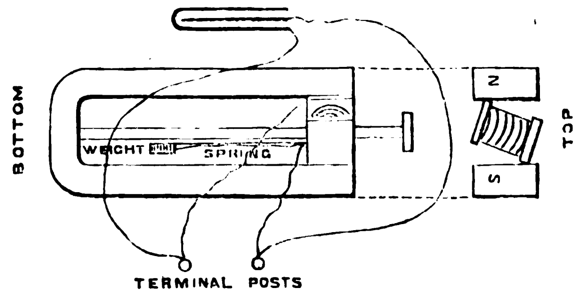

FIG. 3.—The Marcus Machine.

A large horse-shoe magnet constitutes two sides and the bottom of the case. The other two sides are of ebonite, and the top is of brass, carrying a discharging key and handle for setting. The latter forms the top of a vertical shaft extending between the bars of the magnet from top to bottom. Between the poles, it carries an armature of soft iron in shape like a square-headed spool. This spool is wound with 280 ohms of insulated copper wire, No. 26 B.W.G., of which the ends are attached to two terminal posts on one of the ebonite sides of the box. These posts are also connected to the opposite plates of a condenser having a capacity of 0·017 microfarads. Between the terminals is also placed a shunt circuit, consisting in part of a long spring held in place by a weight at its lower end.

In its normal condition the ends of the spool stan diagonally between the poles of the magnet, the edges in

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contact with them. To set the instrument for firing, the shaft carrying the armature is turned horizontally through a sufficient angle to bring the opposite edges of the heads of the spool in contact with the magnet, thus developing the force of a strong steel mainspring. On touching the trigger this spring violently turns the shaft and armature back to its normal position, thus reversing the polarity of the core of the coil, and generating a current of electricity in the latter. The inertia of the weight on the spring, developed by the shock, breaks the shunt circuit, and sends the extra current thus induced, reinforced and multiplied by the condenser, through the exterior circuit to fire the fuse.

This instrument requires a conducting tension fuse, like the Abel or Von Ebner; and if more than one be used they must be united in series. It is rather deficient in power, especially where the circuit consists of a submerged cable; but from the size of its condenser and its reversal of the polarity it gives a smart shock.

An attempt failed to directly compare by the equation before given the strength of current developed by this machine with the discharge from the two condensers, because any measurable swing from the latter corresponded to one off the scale from the former. The only method, therefore, was to use the damping magnet, and adopt the Jürgensen machine as a standard, which accomplished the desired result, since the strength of current of that instrument in microfarads had been accurately determined. The following figures give the results of this comparison, which was made in 1875, and repeated in 1880:—

Jürgensen,	9·5°;	Marcus,	29·2°;	ratio by equation,	3·0 times
„	14·5°;	„	50·2°;	„ „	3·3 „
„	18·4°;	„	60·0°;	„ „	3·1 „
				Mean ratio,	3·13 „

Hence the discharge of the Marcus machine is: 2902 × 3·13 = 9083 microfarads, or about six and a half times more than that of the Breguet machine.

(TO BE CONTINUED.)

CORRESPONDENCE.

THE INTERNATIONAL ELECTRICAL EXHIBITION AT VIENNA.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In your last issue, Sept. 15, your special correspondent begins by a reproof of *The Times* correspondent. Of course after that we naturally expect your correspondent to be accurate, and not to publish figures upon mere hearsay, but figures that will bear the test of examination.

Having had some little experience of dynamos I was surprised to read what he writes about the Brush dynamo. It is true he stated "*we are told*" that the current is about ten amperes, and that the average length of arc "*is said to be*" about 2 mm., but then he makes a statement about the speed of E.M.F., viz., that the E.M.F. generated is 2,200 volts, and he draws therefrom the conclusion that the resistance of the Brush lamp was 5·5 ohms (neglecting the resistance of the leads), and from this conclusion of his I understand him to believe that the 2,200 volts is the available E.M.F. in the external circuit, or, in other words, the E.M.F. available for commercial purposes.

This appearing extraordinary, I turned to the latest published account of the Brush machines I am possessed of, viz., Dredge's "Electric Illumination," p. 217, and there I find that the resistance of the Brush lamp is about 4·4 ohms, and the current about 10 amperes, and therefore the E.M.F. of a No. 8 Brush dynamo would be only 1,760 volts.

Now, this is a very serious difference, and it certainly requires some explanation, for if true then the International Electric Company have beaten the Anglo-American Brush Electric Light Corporation in the manufacture of Brush dynamos, for I have inquired of those who ought to know, and I find that not one of them have any knowledge from actual test of any Brush dynamo that will produce even a current of 10 amperes with an E.M.F. of 2,000 volts in the external circuit.

I am engaged on the problem of the transmission of power, and the knowledge that such self-exciting dynamos that would produce a current of 10 amperes and an E.M.F. of 2,000 volts in the external circuit could be obtained in the market would be of great service to me, particularly if they should be the No. 8 that only absorb 39 horse-power indicated to drive them, as I see is stated on the late price list issued by the Anglo-American Brush Electric Light Corporation.

I certainly think it would be of great service commercially, leaving alone the use the information would be to scientists, if either the International Electric Company or the Anglo-American Brush Electric Light Corporation would publish some really reliable and authoritative statistics—other makers do—for the time is nearly past when the public will buy a dynamo costing hundreds of pounds without their knowing more than that it will light a certain number of lamps of a certain *nominal* candle-power, the standard for the *nominal* candle-power varying with the different makers of lamps.—Yours, &c., Z.

[We cannot allow that our Vienna correspondent is in the same position as *The Times'* correspondent. We have not described a machine which the ordinary intelligent visitor will fail to find in the exhibition, we have not gone into ecstacies over a lamp that does not commend itself to experienced electricians, nor have we given credit to foreigners for investigations which are merely extensions of investigations made and published long ago in England. Our correspondent carefully guarded his statements with "it is said" and "we are told," thinking that one or two such expressions were sufficient without reiteration at every sentence. The above letter says "it does not," our correspondent was told "it does," and he gave his information as hearsay. Such information must necessarily be to a great extent "hearsay," for the simple reason that correspondents do not run about with instruments in their pockets, nor can they test every machine, lamp, and apparatus they see. Why should not the "Austrian works" beat the American? From our own knowledge of the men at Vienna we should prefer the Vienna house to any other of the Brush offspring. Messrs. Fairbairn, Wollaston, and Cottam are men in earnest, and the work they do is well done. We quite agree with our correspondent, Z, that "authoritative statistics" should be given. Perhaps our correspondent would be surprised to learn that the figures he gives from Dredge's book are also to be qualified with "they were told," and we may remark that he quotes from a price list as to h.-p., or, in other words, he gives as "he is told." —ED. *E.*]

ARTIFICIAL (SUBMARINE) LINES.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In the obituary notice of my brother (the late Mr. C. F. Varley) which has appeared in your journal, among the inventions mentioned as identified with his name is that of the "artificial line" which represents in every respect a submarine circuit. The suggestion of constructing such lines originated with myself, and a description of them is given in a paper read by me before the Society of Arts on March 30, 1859. This paper was reproduced in the scientific journals of the day.

The artificial line which my late brother turned to such good account was made some years afterwards. The resistance coils forming part of it—which were, I may say, the largest and most complete which had been made up to that time—were constructed by a firm of which I was the active partner, and were made a present to Mr. Cromwell Varley. I furnished him with instructions how to make the induction plates, and these were constructed under his instructions by a workman of the name of Green.

By way of parenthesis, perhaps you will allow me to state I believe I was the first to make paper induction plates which

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would retain a statical charge for any length of time, and, as a matter of fact, my brother tried to dissuade me from doing so, on the ground that paper could not be made to insulate sufficiently; the secret of my success was thoroughly dessicating the paper before immersing it in the insulating material.

I annex an extract from the paper read before the Society of Arts, giving the description of the construction of the artificial line.—Yours, &c., S. ALFRED VARLEY.

2, Hamilton-road, Highbury, N.,
Sept. 18, 1883.

Extract from paper read before Society of Arts, March 30, 1859:—

"The amount of retardation which will be experienced in submarine circuits possessing conductors of varying resistance, and insulated with different thicknesses of insulating material, it appears to me can, comparatively speaking, be readily determined by actual experiment.

"I have for a long time been engaged in designing an apparatus for this purpose, and at the time I arranged to give this paper I fully expected to have had the apparatus completed and to have been able to lay it before you on this occasion, and though I regret not being able to do this, yet I feel I have sufficiently advanced to warrant my explaining the principles of its construction.

"The principles upon which it is based are:—That a body which offers the same resistance as another without reference to its substance or length may, as far as conducting power is concerned, be considered electrically the same. If we make use of a substance or metal of any inferior specific conductive capacity to that of the metal employed in submarine circuits, and also of greatly diminished sectional area, the same resistance as that offered by the very longest circuits can be obtained in a very small compass, and such an arrangement will, as far as simple conductive power is concerned, fairly represent a long submarine circuit.

"The induction which manifests itself in submarine circuits can also be obtained if the conditions for its development are as favourable as they are in submarine conductors.

"The apparatus consists:—

"1st. Of a series of resistances, the values of which are known.

"2nd. Of a series of induction plates, the values of which, when compared with a given surface of a gutta-percha coated wire, are also known.

"3rd. A mechanical arrangement to accurately measure minute periods of time.

"By a combination of the resistances and the induction plates, a conductor which will fairly represent a submarine circuit will be obtained.

"The resistance can be diminished or increased, and the inductive surface can be doubled or halved at pleasure, and thus circuits with conductors of varying length and sectional area, and different thicknesses of insulating material, be imitated, and the law which governs the retardation in the transmission of telegraphic signals determined by direct experiment.

"It may be argued that as the inductive surface in a telegraphic circuit is uniformly spread throughout, a series of induction plates will not present the same conditions, but it is evident they may be divided throughout also, and although they will not then precisely represent what is actually the case, the results will approximate very closely to those obtained from a submarine conductor.

"Perhaps it would have been prudent not to have called attention to an apparatus before its completion. I have done so, however, because I have felt it was due from me to endeavour, at least, to point out how some of the important problems involved in submarine telegraphic communication between the distant station may be resolved."

SEISMIC DISTURBANCES.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Following on the calamitous earthquake of Ischia and Java, if predictions be correct, is to be another, of equal, if not greater, magnitude.

A correspondent of the *Echo* of last week, modestly signing himself "A. H.," foretells that an earthquake may be expected on or about the 22nd. It seems unfortunate that he has not disclosed how he arrived at such a conclusion, and many readers would no doubt express an opinion that "A. H." had simply gone "a-woolgathering," which opinion would a few weeks ago also have been the opinion of the writer, but later investigations and inquiries prove that we may be on the threshold of new discoveries.

Whilst I do not profess to predict the coming earthquake, I am firmly of opinion that it is possible to tell when one is actually occurring, no matter in what part of the globe it may be.

Mr. G. Darwin, in his report to the British Association last year, said, "Oscillations in the bulb of a level were observed at Pulkova Observatory, in Russia, an hour and fourteen minutes after a severe earthquake at Iquique, 7,000 miles away. Similar observations were observed twice previously, and on each occasion it was learned afterwards that earthquakes had taken place some minutes before at places more or less remote."

M. D'Abbadie investigating earth tremors in the south of France by means of reflections from a pool of mercury also found that there were periods of agitation and quiescence in the mercury without any perceptible external cause.

Again, Professor Milne notices indirect evidence of the occurrence of earth pulsations too slow in period to be felt. For example, the earthquake which laid Lisbon in ruins, he says, produced no *perceptible* motion in the soil of northern Europe. That there was movement, however, is proved by the fact that throughout the northern hemisphere slow oscillations of water in lakes, ponds, and canals were observed. The waters of Loch Lomond rose and fell about two and a-half feet every five minutes, and other lakes were similarly agitated.

Electricians have not hitherto troubled themselves with seismic questions, but the study appears to me to be one peculiarly their own, and may be considered to class in interest with magnetic storms or earth currents.

I seldom care to rush into print, but my reasons for troubling you with this communication are as follow:—Mr. John J. Lundy (my collaborator) and I have for many months been making experiments on voltaic batteries, which showed a marked change during the earthquakes of Ischia, and which at the time somewhat confused us. Careful notes were made in the diary of the aberrations, and when the awful results of the earthquake were made public we discovered that the time coincided with the disturbances noted. We therefore determined to be on the *qui vive*, and very shortly afterwards a similar result was experienced in our tests, and we ejaculated "another earthquake." The following morning's papers announced one in the Piræus.

We were unfortunate enough not to take notes when the Java earthquakes occurred, and consequently missed the opportunity of confirming for a third time our experiences.

Now, as Dr. Falk and "A. H." prognosticate another disturbance, I would recommend all interested electricians who may have a simple cell of Leclanché, Fleming, or other battery, with galvanometer at their disposal, to examine them frequently, taking particular notes as to "quantity" and "intensity," also the hour, as well as noting the state of the thermometer and barometer.

There will probably be found an increased power during the earthquake, and no doubt the effects will be felt simultaneously with the eruption.

It would appear from our experiments that inorganic batteries, although not connected or joined to "earth," evidently sympathise with abrupt inorganic changes, whilst, on the contrary, our organic batteries remain uninfluenced by them.—Yours, &c.,

WM. FEREDAY BOTTOMLEY,
National Telephone Company,
London.

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THE ELECTRICIAN.

TO CORRESPONDENTS.

All letters intended for insertion in The Electrician, *or containing questions, must be accompanied by the name and address of the writer. not necessarily for publication, but as a proof of good faith. No notice whatever will be taken of anonymous communications.*

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GROOVES IN ELECTRICAL THOUGHT.

A celebrated writer has said that "true science is highly conservative." This, as are all other generalisations, is only true of particular premises; for science, to be truly great, must be progressive to the utmost imaginative degree. A fear is stealing over us. *Our* science, electricity, seems likely to suffer in public estimation just now from extreme conservatism of principle. Speak to any man ordinarily conversant on scientific subjects about electricity, and the chances are that, although you may get from him clear enough views about the telephone or the electric light, or the submarine telegraph, or about any of the monetarily capitalised branches of electrical science, beyond these his mind will be a blank. These chances, too, would not be greatly limited if we entered into our eductive conversation with many of those who consider themselves entitled to be ranked among the knowing ones. If we remark in a casual way that there are other important applications of electricity, there will be a manner of vacant acquiescence, or perhaps even positive doubt. So absorbed are we in contemplating the brilliant displays of electric light or the wonders of the telephone that we are almost forgetting at times those not so attractive but infinitely more wonderful applications that arise from the development of the laws of electrolysis. Not many years ago electrolytically deposited copper was used in the laboratory only; now a single firm will deposit tons upon tons annually. A regular trade is established in refining copper, another in depositing it upon telegraph wire, again upon printing blocks, all by electricity; and as to the nobler metals, should the perturbed spirit of Jack Sheppard assume its mortal coil, and as a burglar "go a-burgling," the "electro" business would in itself afford a sufficient sequential punishment. All this, which is daily before our eyes, we scarcely appreciate at its full value. Though we have before now called attention to this want of due appreciation, our pages have little to chronicle of fresh work, or even attempts in the direction of a further study of electrolysis. It is only the student or specialist who knows of the steady endeavour to use the current to reduce zinc ores, to clear the phlegm of alcoholic distillates, to age wines with proper effect, all with more or less complete success. We venture to prophesy—dangerous even as prophesying may be, and little as the prophet is appreciated on his native heath—that at no very distant epoch electricity and the alkali trade will be very nearly related. And all these things would be done much more quickly if inventors would try to raise themselves out of the grooves and ruts of thought in which they seem bound to run. Many and many a "new" invention in secondary batteries, for example, have we waded through to find the use of the same metal in pretty much the same way but set upside down or in some other plane; and we live to be thankful for that Divine ordination that prevented the changes being rung in a fourth dimension of space.

Yet it is not only in the application of electricity that we are in danger of cutting too deep a groove for easy subsequent emergence; we are getting far too easily convinced that we are in full possession of knowledge of the means of its generation. Its generation is at present intermediary, that is, we are largely dependent on the steam or gas engine and the water-wheel for our electricity, and because we are now so dependent, we shut the wide-open door of the future, and lock it with doubt and scepticism. Verily, we are returning to the days when our fathers laughed at an idea of a locomotive, and deemed a steam vessel heterodox. Is this "groove-ism," this false conservatism to ever cease? Let us look at this all important question of the generation of electricity economically, with eyes in which all imagination is not entirely blotted out, and by a little begging of the question, a little less assumption than Euclid has used in the proof of a geometrical problem, see what there is before us.

"Because things are, they have always been so," is, according to a well-known French author, a social aphorism; and we very well know that because things are, so are we inclined to let them remain. Because we have made great and rapid strides in the construction of dynamo-electric machines, it should not follow that these afford the only means of procuring electricity. There are besides very numerous instances where machinery of any description is totally inapplicable, and we believe there are not a few cases where electricity can be obtained as a bye-product at a nominal cost. For example, in the precipitation of copper from its solution by iron or lime, immense volumes of electric currents are easily made available. These might be made to charge a system of accumulators, while any required electromotive force could be arranged by suitable switches, the current carried long distances, and sold for light or power at great profit. In fact, nearly all large chemical works may become generating stations, and electricity may in the immediate future become a valuable bye-product to the manufacturing chemist. At home, too, in our houses we

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largely waste heat, and heat is easily transformed into electric current by the thermopile. There is also a strong tendency at the present time to re-investigate the subject of primary batteries, and this tendency should be encouraged and assisted, for whilst it is true that zinc cannot be economically consumed to produce electricity only, it may be advantageously used when it yields a marketable product besides. Because our fathers rode in coaches and we ride in Pullman cars and carry our hotels with us electrically lighted, it does not necessarily result that we have attained the point of maximum. The dynamo machine itself was known many years ago; it has comparatively recently been made useful. The same improvement is equally likely in other sources of electricity. *But*, Mr. Inventor, *festina lente* must be your motto.

RICHARD SIGISMUND KARL WERDERMANN.

We regret to have to announce the death of Mr. Werdermann, which took place on Saturday last, after a long and painful illness. Born in 1828, in Silesia, he was brought up to the profession which at that time was considered the only one befitting the descendant of an old patrician family—namely, the army; but the narrow life of a Prussian artillery officer of that period did not satisfy a mind eminently suited to a more scientific and useful vocation, and after quitting the service Mr. Werdermann established himself as a civil engineer in Paris.

There he made the acquaintance of M. Gramme, then a workman as yet unknown to the world, and took a lively and practical interest in the development of the Gramme machine. The year 1870 brought trouble to the Germans living in Paris, and Mr. Werdermann was amongst those who emigrated. But this did not end his relations with M. Gramme. So convinced was he from the first of the merits and ultimate importance of the Gramme machine that he bought M. Gramme's English and American patents, and came to England to introduce the new invention here.

He was the first to show the transmission of power by Gramme machines before the Institution of Civil Engineers in London; he also proved that the Gramme machine could do all the work which hitherto had been done by batteries, and, in fact, had a small machine working part of the telegraphic service in the General Post Office. In 1875 he exhibited from the roof of Charing-cross Hotel an electric arc light fed by a Gramme machine.

The invention which has come most prominently before the public is the Werdermann semi-incandescent lamp, first exhibited in a workshop in Euston-road. At that time the great question of the day was the sub-division of the electric light. Incandescence lamps were unknown, and the few arc lamps then in the market were far too expensive, too complicated, and too powerful for domestic lighting, and, besides, it was considered that they could not be worked in parallel arc. It was then that the newly-invented Werdermann lamp was hailed as the solution of the problem, and gave a strong impetus to the young science of electric lighting just struggling into existence. The first lamps exhibited in Euston-road were of the most primitive design, but with the assistance of M. Napoli, of Paris, artistically-designed electroliers were added, and those of our readers who visited the president's room and the theatre at the Paris Exhibition of 1881 will remember the charming effect of the soft white Werdermann light.

It is perhaps not so well known that Mr. Werdermann also invented an electric candle, which was used by the original Jablochkoff Company. The last time he came before the notice of the public was at the recent Crystal Palace Exhibition with the Lea-Werdermann arc lamps, a number of which lighted the Alhambra Court.

Mr. Werdermann was a true inventor, rich in ingenious ideas, never sparing pains or expense to carry them into successful practice, but neglecting the commercial part. His kindly nature, simple honesty, and almost childlike confidence in everybody he came in contact with made him universally liked; but it also prevented him from reaping personal benefits from his inventions. Disappointments, lawsuits, and vexations in many ways were his lot, gradually undermining his health. It is characteristic of his high scientific integrity that last year, when, during the electric light mania, inventors could ask and obtain almost any price for their patents from speculative companies, he, believing that no business could be done by a company saddled at the outset with heavy patent charges, refused to have anything to do with such matters. In him we have lost one of the early pioneers of electric lighting. Mr. Werderman leaves a widow, three daughters, and a son.

TECHNICAL EDUCATION IN NOTTINGHAM.

In connection with the Trades Union Congress held last week in Nottingham, a meeting took place in the Albert Hall for the consideration of the question of technical education, and it was attended by nearly 3,000 working men. It appears that an organisation exists in Nottingham known as "The Trades Council of Learning." It consists of representatives of the several trades unions, together with a few other persons interested in education, and its office is to consider the educational requirements of the artisans of the town, and by means of memorials, conferences, or in other ways to influence the School Board, the committee, and professors of the University College, or any other educational body which may be able to further the objects which the council deems desirable. By contributing towards the funds of the University College the trades council has secured a representative upon the committee of that institution, and a short time ago a small committee was appointed by the council to confer with one of the college professors respecting the character of the technical teaching required by those engaged in the lace and hosiery trades. Such a trades council would, doubtless, prove of service in towns like Manchester, Liverpool, Birmingham, Leeds, Bristol, Sheffield, and Newcastle-on-Tyne, where large trades unions as well as important colleges exist and want to be made to help one another. On the occasion of the visit of the Trades Union Congress to Nottingham, the meeting to which we have referred was convened by the Trades Council of Learning, and the chair was taken by Mr. S. Morley, M.P. The first resolution, which was in favour of technical education generally, in order to place British trade in a position to compete on equal terms with that of foreign countries, was proposed by Mr. Summers, M.P., seconded by Mr. Woodall, M.P., and supported by Alderman Gripper. The second resolution favoured technical education as applied to Nottingham, and referred in favourable terms to the technical school about to be opened in connection with the University College in that town. This resolution was proposed by Colonel Seeley, M.P., seconded by Alderman Cropper, and supported by Professor Garnett. It is almost unnecessary to state that the two resolutions, like the vote of thanks to the chairman, which was proposed by the Mayor and seconded by Mr. Broadhurst, M.P., were carried unanimously and enthusiastically.

In the course of the addresses some account was given of the technical school about to be opened in Nottingham. This school is being equipped and supported partly through the liberality of the Drapers' Company and partly through the contributions of manufacturers and others in the town, particularly Mr. Councillor A. Jacobi. In it and in the laboratories and class rooms of the college provision will be made to meet the requirements of lace makers, hosiers, engineers and electricians. The college is already provided with chemical and physical laboratories and lecture rooms. The new school consists mainly of workshops, and will provide accommodation for about 40 students working at the same time. It will be furnished with tools for pattern making and joining, a cupola, a brass furnace, smith's hearth and tools, a 10in. and a 7in. self-acting sliding, surfacing, and screw cut-

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ting gap lathes, and several smaller lathes, a 6ft. planing machine, and 8in. sloping machine, a milling machine, shearing and punching machine, drill, &c., besides the usual hand tools, surface plates, Whitworth gauges, &c. All the tools are new and from the best makers, with all modern improvements, so that the shops will perhaps be as well furnished as any similar educational establishment in this country. The shops will be lighted with the electric light, and a 20 h.-p. Robey engine has been provided for this purpose. In these schools students from all parts of the country will have the opportunity of attending a complete course of practical instruction in mechanical and electrical engineering, under the supervision of two former Whitworth scholars, viz., Professor William Garnett, late Fellow of St. John's College, Cambridge, and Demonstrator of Experimental Physics at the Cavendish Laboratory under the late Professor Clerk Maxwell, and Dr. John Ryan, scholar of King's College, Cambridge, and D.Sc. in Electricity and Magnetism of the University of London; but one of the principal objects of the workshops is the construction of a museum series of mechanical models to afford a practical training in the elements of mechanism for those men engaged in the lace and hosiery manufactures who desire to become foremen in their shops. It is understood that in the course of a few years a sum of money will be presented to the Corporation for the erection of a museum affording opportunities for the exhibition of such a series of models, as well as the reception of machines and models of historic value. The physical laboratory of University College is provided with a well-appointed room for electrical testing, and, with the addition of such a complete workshop as that to which we have referred, the Electrical Engineering School at Nottingham ought soon to be making its influence felt in improving our systems of electric lighting.

THE INTERNATIONAL ELECTRICAL EXHIBITION AT VIENNA.

(FROM OUR SPECIAL CORRESPONDENT.)

III.

Strolling through what may be looked upon as the pit of the rotunda, and carefully looking through the exhibits, we notice that here the various Governments have their pavilions and their exhibits. There is little among these exhibits that can be termed new, they being principally devoted to telegraphic and telephonic apparatus. Still, the earnest student will find something of interest in every direction; he will find, for example, in the Belgian and Austrian exhibits, specimens of the tools and materials used for constructing the lines in those countries, and it will be a good exercise for him to ascertain the why and the wherefore of the modifications in tools, insulators, &c., which are shown. The apparatus consists mainly of telegraphic apparatus, Morse instruments, varying perhaps somewhat in detail, but as a rule involving similar parts, as well as, of course, being similar in principle. Relays by the score—nay, we might almost say by the hundred—Hughes's type printer and its modifications, so largely used upon the Continent, telephonic receiving and sending apparatus, central station switches, &c. These, as we say, form the staple of the governmental exhibits in the body of the rotunda. In the Belgian section is a feature we wish could be extended, viz., the books and pamphlets upon the apparatus, so that one may not be left in ignorance upon any point. If, for example, the student is perplexed by

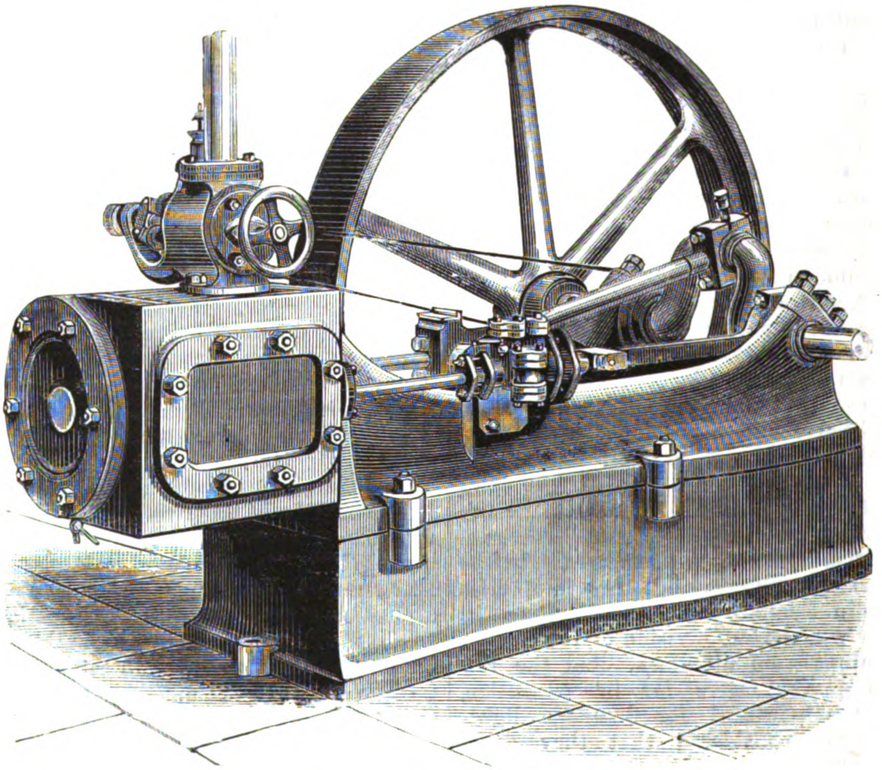

FIG. 1.—Hindley's Engine.

hearing of Hughes's apparatus arranged for duplex work, he can quietly study the excellent diagrams upon the table. In one of these publications, the "Guide Official de la Correspondence Télégraphique, &c.," we find that on January 1st, 1883, Belgium had 6,250 kilometres of lines, involving a length of 28,000 kilometres of wire, between 1,017 offices, the number of instruments being 1,684. There is no doubt that the Belgians are fully alive to the value of a good system of intercommunication. A paragraph in our notes of a recent issue mentioned telephonic experiments that were being carried out between Antwerp and Brussels. We were present at Brussels some part of the time these experiments were being carried out, and can testify to their success. It is to be noted that the speaking was heard clearly and distinctly, and that evil effects of induction were entirely obviated by the adoption of the sys-

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tem of running the wires as explained by Mr. Preece, at the meeting of the British Association, at Southampton, last year.* We should, however, remember that telephony between Brussels and Antwerp is an easier matter than between Manchester and Liverpool, and Edinburgh and Glasgow, which has been successfully carried out in England. It must be remembered also that the troubles from climatic influences on insulation are not so bad upon the continent as in England. The most important fact about the Antwerp-Brussels experiment is that it is one of a number of experiments to utilise the ordinary telegraph wires for telephonic purposes without interfering with the telegraphy. The system upon trial in Belgium is that suggested by Van Rysselberghe.

Besides the ordinary telegraphic apparatus referred to, Belgium, as does Denmark, Austria, &c., shows a fully equipped waggon for field telegraphy. The instruments used in these field telegraphs are mostly of Siemens type. The appointments and arrangements differ slightly, but as similar waggons were exhibited at Paris, it is sufficient to say they are also to be seen at Vienna.

In the gallery between the English pavilion and the court mentioned in a previous letter is to be found one of Jürgensen's machines, with field magnets inside and outside of the Gramme armature similar to the machine shown at Paris. A smaller machine of this type will be found at work in the boiler house, the motive power being obtained from a Hindley 12 horse-power horizontal engine. This engine (Fig. 1) is similar in design to that which obtained a gold medal at the Crystal Palace. The bearings are long and heavy, to suit continuous and hard work. The governor is one of Mr. Hindley's own design, maintains a uniform motion, and is simple. This engine has cylinder 11in., stroke 15in., with a fly-wheel 66in. diameter, making 110 revolutions per minute. It is unnecessary to describe the dynamo, because it was described and illustrated in our issue of Oct. 8, 1881.

Bernstein's incandescent lamp has perhaps gained a certain amount of notice from the unscientific, and even the scientific press, which in these days of incandescent lamps is rather singular. Writing, as we do, away from books of reference, it is difficult to say what has been the aim of the makers of incandescent lamps, but, subject to correction, we are of the opinion that the tendency of late has been to manufacture high resistance lamps which for a given candle-power require a small current. The normal candle-power we take to be from 16 to 20 candles. Edison's lamps have comparatively a high resistance, and require less than an ampere of current. Swan's lamps have been made of higher and higher resistance, and the requisite current decreased accordingly. M. Bernstein, however, takes the opposite view, and brings forward a low resistance lamp requiring a large current—that is to say, a current of three or four amperes. The following measurements were taken as a guide to the requirements of this lamp. The figures must be taken at approximate only, and not rigidly exact. The E.M.F. as terminals of lamp was 26·4 volts, and the current, giving a fair light 4·7 amperes. This would give about 6 lamps per horse-power, and it was estimated that this would give some 4 watts per candle. The best results gave 3·5 watts per candle-power. These experiments were carried out with the secondary batteries of the Electrical Power and Storage Company. With more cells the following results were obtained:—E.M.F. at terminals, 28 volts; current, 5·44 amperes, which would not give 5 lamps per horse-power. The candle-power was greater, and the watts per candle-power fractionally less. With greater battery power still similar results were obtained, the watts per candle-power being fractionally reduced. But suppose, now, these results are as good as those obtained with Swan, Edison, Maxim, Fitz-Gerald, and other lamps so far as regards candle-power per horse-power, let us see the effect of adopting the lamp. Take the case of the use of an Edison machine giving 100 volts E.M.F. and a 1,000 ampere current. A thousand Edison A lamps could be used in single multiple arc—that, is suppose the lamps to require 1 ampere current and 100 volts, or rather less E.M.F. Using Bernstein lamps, requiring 4·7 amperes and 26 volts, or say 25 volts E.M.F., we should have to put the lamps in compound multiple arc, 4 in series, and about 210 or 212 branches, giving a total of nearly 850 lamps. No doubt these might give an equivalent candle-power, but the question to consider is single or compound multiple arc. Bernstein lamps will require, if used in single multiple arc, a machine designed somewhat after the fashion of a plating machine to give an enormous current at a low electromotive force. Then in large installations comes in most disadvantageously the question of cost of mains. Bearing in mind that we want all the heat in the carbon and none in the leads, and that the heating effect is expressed by $C^2 R$, and therefore the less the resistance of the leads the less loss occurs. Now, with such low resistance lamps the resistance of the conductors, unless of large section, will bear a large ratio to that of the lamps. If the conductors are of large section it means increase in the weight of metal, and a great increase in the cost of the mains.

It may be admitted that low resistance lamps can be constructed to take very large currents and not to break down, but again we have to consider the normal candle-power per lamp best suited for lighting interiors, and that seems to be somewhere between 15 and 25 candles. In one of the experiments with a Bernstein lamp with a large carbon, we obtained approximately a photometric power of about 90 candles, using 24 Sellon-Volckmar cells in series, and having a current of about 9·77 amperes. That Mr. Bernstein's lamp as a lamp will give a good light, bear a large current without breaking down, and has certain advantages we are not prepared to deny, but we must be allowed to doubt its practical utility when used on a large scale. Of course, our conclusions may be altogether incorrect; time will prove this, but we have at any rate indicated our reasons, whether they be good, bad, or indifferent. We find we have not yet stated the peculiarity of the Bernstein lamp. Its carbon consists of knitted fibre, carbonised, the carbon thus forming a hollow lace-like cylinder.

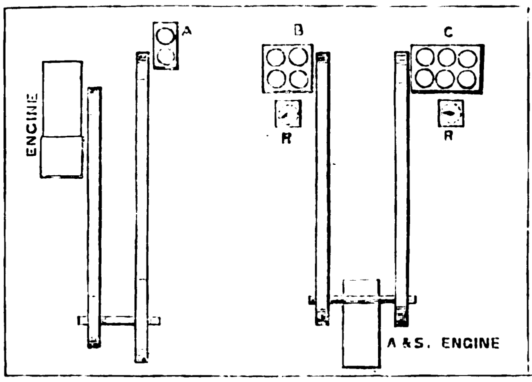

Fig. 2.—Plan of Edison Installation at Vienna.

The Edison exhibit, as is usual in first-class exhibitions, claims a prominent notice. The apparatus shown, however, is for the most part of a well-known type, and has been previously illustrated in our columns. This installation has been made under the superintendence of Mr. F. Jehl, who, as may be remembered, carried out the lighting at the Brünn Theatre. The arrangement of the machines will be seen from the plan in Figure 2. A is a Z machine, having one magnet; B an L machine, with two magnets; and C a K machine, with three magnets. The B and C machines are coupled parallel, and each has a regulator, R R, these regulators, however, being connected parallel. The B and C machines are driven by an Armington-Sims engine, with pulleys at each end of the axle. The machine A is driven by an engine by Rack, of Vienna. The dynamos supply current to over 400 lamps, distributed as follows:—110 lamps in the restaurant, 150 lamps in the Art Gallery, and 140 lamps in some of the rooms, which have been furnished and lighted to show the adaptability of the incandescent lights to interior lighting. Besides these a variety of lamps are arranged upon a large table on one side of the stand. These include

* *Vide Electrician*, Vol. IX., p. 389, where illustrations of this system will be found.

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specimens of most, if not all, the Edison lamps in use, and switches being provided, the great amusement for visitors is to turn a lamp off and on. Here, as is always the case whenever an Edison Company exhibits, great care has been taken to have everything ready at the time appointed and to obviate any danger of a break down. We feel rather strongly upon the question of preparedness or unpreparedness, and we know it is very disappointing to visitors to come and find a number of exhibits not ready. Many visitors cannot pay a second or third visit at intervals of a few weeks to see the apparatus put into position since their first visit. Even at this late day, September 14, some of the English exhibitors have made no show at all—possibly they do not intend to exhibit. To return, however, to the immediate subject in hand. The only new apparatus in the Edison exhibit is a cigar lighter. Inveterate smokers have been heard to declaim against the introduction of the electric light because the incandescent lamp does not offer certain facilities to them in the indulgence of their favourite habit. A variety of ingenious devices have been contrived to provide the required light, and Edison has this device among the number. Fig. 3 shows his cigar lighter. A cylinder, A, which can be screwed against the wall, carries

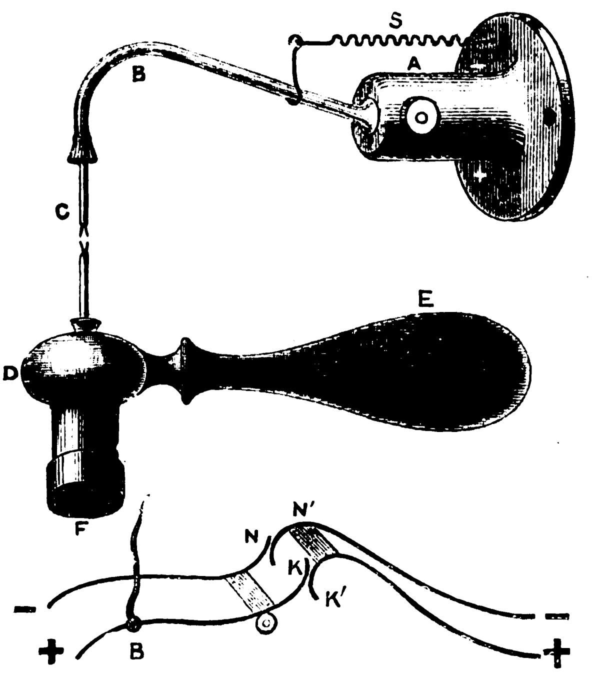

Fig. 3.—Edison Cigar Lighter.

the contact making parts. B is a curved brass arm carrying the wires. This arm is movable. Normally it is kept in the position shown, because the handle E is weighted, and under this condition there is no contact. When, however, the lighter is to be used, it is lifted up by means of the handle E, the spring S then comes into play, pulls back B, and makes contact. D is the holder for the plug F. The latter consists of a thin asbestos disc sewn across with platinum wire. One end of the platinum is connected to a side contact, the other with a bottom contact on the plug. These contacts when the plug is screwed into the holder bring the platinum into contact with the conductors. The method of making contact in the cylinder A is shown at N N' K K'. When the spring S raises the arm B, N is brought into contact with N' and K with K', thus completing the circuit. We suppose there is a good deal of inquisitiveness all the world over, otherwise we should not record that an inquisitive native with an unpronouncable name took up one of these cigar lighters and tried to pick it to pieces with his pen knife to find what was inside. He evidently wanted to see "what maksh the wheels go wound." This little apparatus has caused as much curiosity as Mr. Preece's electric pin. We expect the fair Viennese will, during the coming season, think society's demands have not been complied with unless they can glitter with a tiara of incandescent lamps.

The English Post Office collection, now that it is practically complete, is a fine exhibit, second to none in interest in the whole exhibition. The apparatus exhibited, however, is, for the most part, not new, and has been fully described at different times in our pages; but its great interest lies in the historic continuity it presents in matters telegraphic. The apparatus is displayed upon four stands, one of which is devoted to historic apparatus, two to the more modern instruments of telegraphy and telephony, and one to the materials and tools, &c., used in the erection of lines. Among the historic apparatus we noticed the signalling instrument used in 1840 upon the Blackwall Railway for starting and stopping trains, also Henley's single and double-needle magneto instruments, Cooke and Wheatstone's 5-needle instruments, their 4-needle instrument of 1838, and their 2-needle instruments of 1837 and 1842, as well as Wheatstone's original A B C instrument of 1842, and Nott's step by step instrument of 1843. Then we have Bain's I. V instrument of 1843, and his chemical telegraph of 1850. We cannot help thinking that Bain's work is but too little known and appreciated by his countrymen. The original 1837 galvanometer of Wheatstone is also among the exhibits. Another name—the name of one who is now lost to us—is represented by a secondary battery used in 1855, and by various forms of lightning protectors. This name is that of Varley, one of those early pioneers and workers to whom cable telegraphy at any rate owes much. Among this historic apparatus is the magneto-electric machine of 1846, called the Thunder-pump, used by the Elec-

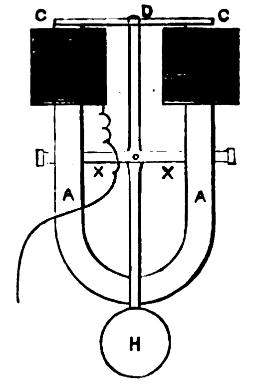

Fig. 4.—The Thunder Pump.

tric Telegraph Company for releasing the mechanism of electric alarums or bells. We do not remember to have illustrated this ancient apparatus, which retains, however, much of its vitality to-day, and hasten to make good our remissness by a rough plan of the apparatus. A A (Fig. 4) is a strong permanent magnet, upon the poles of which are the coils C C, connected by D. The handle H rotates upon the axle X X. When H is depressed the coils are raised, and *vice versâ*, and thus a current is obtained. The modern instruments shown include specimens of almost all in use—the A B C instrument, so largely used on private lines, single and double needle instruments, Bright's bell, single and double current duplex, quadruplex, &c. Most, if not all, of these instruments were shown at the Crystal Palace, and such as were unfamiliar were then illustrated and described. Some improvements have been introduced into the telephonic apparatus, but these will, we understand, be described in a paper to be read by Mr. W. H. Preece, F.R.S., before the British Association, and we will, therefore, forego any description we might be prepared to give to the more complete paper which no doubt will be available to our readers in due course.

The Western and Brazilian Telegraph Company.—The traffic receipts of this company for the week ending 14th September, 1883, were £2,204, after deducting the "fifth" of the gross receipts payable to the London Platino-Brazilian Telegraph Company.

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A HORIZONTAL CAPILLARY ELECTROMETER.*

BY M. CH. CLAVERIE.

A glass tube, V, with an internal diameter of from ·005 metre to ·006 metre, is drawn out by the blow pipe, so as to give a slightly conical capillary tube, having an internal diameter of ·001 at the most. The capillary portion is curved as shown in Fig. 1, and the whole is fixed on a vertical board supported by a footpiece with three levelling screws, together with a second tube, V′, closed at its lower end, holding a little mercury and acidulated water, in which the end of the capillary tube is immersed. The space A to B is divided into millimetres; *a* and *b* are platinum wires; these are connected, mercury is poured into V, the apparatus is inclined until the mercury flows drop by drop into V′; the apparatus is then righted until A B is about horizontal, and little by little more mercury is poured into V until the mercurial meniscus† in A B is close to the end B near V′. This is

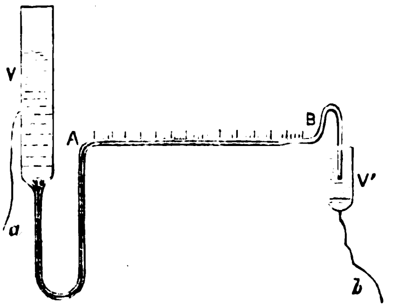

FIG. 1.—Capillary Electrometer.

the zero of the apparatus. If now *a* be made negative to *b*, the meniscus will retreat from B towards A, and the displacement is always the same for the same electromotive force if the apparatus is well made. But it is rare for an apparatus constructed without special precaution not to have several zeros, and for the same electromotive force not to produce several different displacements. If the variation in diameter of the capillary portion is studied by sending through it a

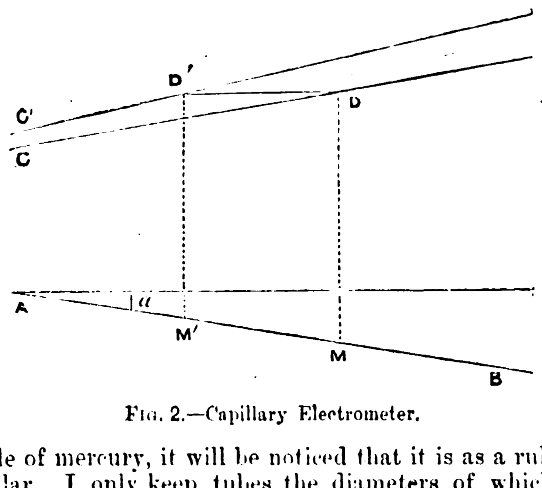

FIG. 2.—Capillary Electrometer.

globule of mercury, it will be noticed that it is as a rule very irregular. I only keep tubes the diameters of which vary over a certain length as the ordinates of a straight line, and it is the corresponding portion of the tube which serves to form the rectilineal and horizontal part A B of the electrometer.

The heights of mercury that the meniscus placed at different points of the tube can support are, according to Jurin's law, in inverse ratio to the diameters of the tube, and accordingly vary as the ordinates of a hyperbolic curve, which does not materially differ from a straight line in the part corresponding to the capillary branch A B.

Let us suppose that A B makes an angle a with the horizon by sloping downwards from A. From the different points of A B (Fig. 2) draw verticals on which set off lines equal in length to the heights of mercury that the meniscus placed within these points of the tube can support, the wires *a* and *b* being in connection.

The ends of these determine a line, C D. If between *a* and *b* we cause a difference of potential, *e*, the heights of mercury sustained by the meniscus increase by a fraction of themselves proportional to *e*, and we have a fresh line, C′D′, which meets A B at the same point as C D. If the meniscus is at first in M, it reaches a point M′ such that the ordinates of C′ D′ and C D passing through M′ and M are equal.

If l represents the length A B, a and b the heights of mercury indicated between A and B by the meniscus when $e = 0$, x and x' the distances of M and M′ at the point where A B meets C D and C′ D′, d the displacement M M′,

$$d = \frac{k\,(b-a)\,x'\,e}{b-a-l\sin a} = \frac{k\,(b-a)\,x\,e}{(b-a)\,(1\times k\,e) - l\sin a},$$

The variations of x are always small enough to enable us to consider x' as materially constant; for example, x being equal to $4\,m$, the greatest difference between x' and x will be $·20\,m$. We see, therefore, that the displacement d is proportional to e. Further, we see that the sensitiveness increases with a up to the point where $b - a - l\sin a = 0$; for this value of a, C D would be horizontal, and the apparatus would no longer have a zero. For a higher value of a, it will be readily seen that only a position of unstable equilibrium would remain for the meniscus, and that if it were brought to a certain point in the tube it would, in general, oscillate, now to this side, now to the other, up to a point where it would leave A B.

If the tube be inclined by elevating the end B, the sensitiveness is decreased. Therefore, by means of the levelling screws, the sensitiveness of the apparatus can be determined. With a displacement of ·150m. for an electromotive force of one volt, the zero is perfectly fixed, and the stoppages of the meniscus are very well defined.

* From the *Journal de Physique* for September.

† The curved extremity of a mercury column is called the meniscus.

A HISTORY OF ELECTRIC TELEGRAPHY TO THE YEAR 1837.

BY J. J. FAHIE, MEMB. SOC. TEL. ENGS. AND ELECS.*

NOTE.—Being anxious to make his History as complete as possible, the Author will be grateful to his readers for any information, no matter how small, in relation to the subjects treated of in these pages.

CHAPTER III.—TELEGRAPHS BASED ON STATIC, OR FRICTIONAL, ELECTRICITY.

(CONTINUED FROM PAGE 419.)

1828.—TRIBOAILLET DE ST. AMAND'S TELEGRAPH.

In this year Victor Triboaillet de St. Amand proposed a single line telegraph between Paris and Brussels. The conducting wire was to be varnished with shellac, wound with silk, coated with resin, and enclosed in lengths of glass tubing carefully luted with resin; the whole being substantially wrapped and water-proofed, and, finally, buried some feet deep in the earth.

Nothing is known for certain of the signalling arrangements, and it is even doubtful to what class the invention belongs; as, while a strong voltaic battery was the source of electricity, the receiving instrument was to be an electroscope, or electrometer. Vail ("Electro-Magnetic Telegraph," 1845, p. 135), Prescott ("History, Theory, and Practice of the Electric Telegraph," 1860, p. 394), and American writers, generally, evidently regard it as belonging to the electro-magnetic form; while Zetzsche ("Geschichte der Elektrischen Telegraphie," 1877, sec. 6, para. 11), and Guerout (*La Lumière Electrique*, March 3, 1883, p. 263) class it amongst those based on static electricity.

The author appears to have provided no particular form of alphabet, or code, leaving it to each person to devise his own out of the motions, of which the electroscope was susceptible.

1830.—RECY'S TELEGRAPH.

In a *brochure* of 35 pages, entitled "Télétatodydaxie, ou Télégraphie Electrique," Hubert Recy describes a crude system of syllabic telegraphy. Although his little book was not published in Paris until 1838, we gather from the text that his plans were laid as early as 1830. At page 34 he writes:—"I had a thought of

* The author reserves all rights of translation.

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offering [my teletatodydax] to civilisation, a thought fixed and durable, because, notwithstanding some respectable opinions, I believe it useful to man in seasonable times; but I did not wish to make it known in 1830 and during the stormy years that followed."

His telegraphic language is composed of (*a*) four initial vowels, (*b*) fifteen diphthongs, and (*c*) six monosyllables, all of which, with their various combinations, are figured in tables at pages 5 and 6 of his pamphlet.

The line wires were to be of iron, enveloped in wax-cloth, then well tarred and enclosed in a leaden tube to preserve them from moisture, and so prevent the diminution of the force of the electric spark. They might be placed at some feet underground along the high roads like water pipes, and those parts destined for submersion in water, across the sea, for example, to England, should be prepared with the greatest care, so as to entirely exclude the moisture.*

In certain cases, he says, the metals of the railway could be used as lines of communication for the conveyance of the electric spark, and nothing would be easier than to put them into a condition to fulfil this important function, each rail representing a line.

At the sending station were the electrical machines for producing the sparks, and electrometers, one on each wire, for indicating the passage and strength of the same. At the receiving station the lines terminated in needles, or points, which dipped into little cups containing some inflammable substance like alcohol, or even hydrogen gas. A sufficient number of these cups was always at hand, ready charged, to take the place of those exploded in the course of correspondence.

The line wires, which were bound together side by side, were marked, the one, say the right, with the *units*, or vowels, and the other, the left, with the *fives*, or diphthongs. As a general rule in teletatodydaxy that vowel termination which aids most in the expression and comprehension of a word, or phrase, is é (*é fermé*); for example—"Méhémet-Ali, vice-roi d'Egypte, fait travailler à la découverte des mines de Syrie" might be transmitted thus—Méhémété élé, vécé ré d'Égépété, fé térévéléré é lé dékévéréte dé méné dé Séré, in pronouncing which rapidly, and without dwelling too much on the é, the ear would easily comprehend the sense.†

After showing, pages 10 to 14, how this sentence should be transmitted, the author says that every conceivable communication could be made in the same way, each syllable being expressible, according to his tables, by vowels alone, or by vowels and diphthongs combined. One class of vowel, or *units*, was represented by one spark in the right line, a second class by two sparks, a third by three, and a fourth by four. Each diphthong (and monosyllable), or *five*, was similarly represented by one, two, three, or four, sparks in the left wire, either alone, or immediately followed by one, two, three, or four, sparks in the right wire, according as the syllable was in the first, second, third, or fourth, class of *fives*, and in the second, third, fourth, or fifth place of the class. Thus, Ba, which is in the first place of the first class of *fives*, would be represented by one spark in the left wire, while Pa, which is in the third place of the second class, would be indicated by two sparks in the left wire for the class, followed by three sparks in the right for the place.

In case it would be impossible to establish two wires, on account of the expense, or from any other cause, the author shows how one wire would suffice, the signalling requiring, in this case, only a little more time, and a little more attention. The vowels would be transmitted as before, but the diphthongs and monosyllables would be expressed by two sparks in rapid succession *te te*, the interval between being much less than that between the vowels; and, for greater clearness, the end of each word would be notified by the signal A, which would be neither the end of the last word, nor the commencement of the following.

If desired, each letter, or character, of the teletatodydaxical tables could represent some conventional phrase, or the sparks could stand for figures which would belong to words and phrases in a dictionary, or code.

The author concludes a rhapsody on the uses which the great Napoleon would have made of teletatodydaxy had it been then discovered‡ in words, which, in these days of their realisation, deserve to be remembered:—"If, in the time of Napoleon, gas-lighting had been as general as it is now, and some one had told him: by means of the teletatodydax you can, in less than a second, light all the lamps of the capital at the same time and as one lamp; or, as everything sublunary has disadvantages as well as advantages, you cannot guard yourself against the malefactors who would sow infernal machines under your feet, would fire your ships, arsenals, powder-magazines, and monuments—enemies all the more difficult to discover, since they can perpetrate their crimes from afar by means of the wire; would Napoleon have shut his eyes and ears to these facts? No, such advantages and disadvantages combined would certainly have fixed his attention, and, not being able to annihilate a power of which he would wish only himself to know the force, he would so control it as to draw for himself all the advantages, and, at the same time, prevent others from putting it to wrongful ends" (page 34).

1836.—Davy's Telegraph.

This, with Mr. Davy's other and wonderful inventions in telegraphy, has been so recently described in these pages that we need not do more now than refer our readers to *The Electrician*, for July 7, 1883, p. 181, and three following numbers, for full details.

1837.—Du Jardin's Telegraph.

Du Jardin, of Lille, whose fast-speed type-writer was used, for a short time, in 1866, on the late Electric and International Telegraph Company's lines, was occupied with the telegraph as far back as 1837.

His first ideas on the subject were, in that year, communicated to the Paris Academy of Sciences; but, except the bare title of the paper in the *Compte Rendu*, for July 10, 1837, nothing appears to have been published. We learn, however, from Professor Magrini* that he proposed to erect a single wire between the Tuileries and the *Arc de l'Etoile*, and to employ an electric machine and a sensitive electroscope for the signalling apparatus.

If none of the contrivances that we have described in the foregoing pages ever passed the stage of experiment, it is because they, one and all, laboured under two heavy disadvantages—the one, that they were in advance of the age, and the other, the intractable nature of the force employed, rendering its transmission to any distance impossible in the open air, and exceedingly difficult through buried wires.

Of course, if no other form of electricity had been discovered, some of these inventions—notably those of Alexandre, Ronalds, and Dyar—could be improved, so that we should have at this day electric telegraphs, not so simple, nor with so many resources as those at present in use, but yet instruments that would fulfil the grand object of communicating at a distance with lightning speed. Many practical difficulties would, however, remain, which, even with our present extended knowledge, we could not entirely obviate, and which would, therefore, have hindered their complete success.

If, then, none of their authors, though through no fault of his own, deserves the title of inventor of a really practicable and commercially successful telegraph, we must, at least, give one and all the credit of having fully appreciated its importance, and of having dedicated their energies to the accomplishment of the task they set themselves in the face of many difficulties and disappointments.†

(TO BE CONTINUED.)

BRITISH ASSOCIATION.

PRESIDENT'S ADDRESS.‡

Since our last meeting we have been deprived of three of our most distinguished members. The loss by the death of Professor Henry John Stephen Smith is a very grievous one to those who knew and admired and loved him, to his University, and to mathematical science, which he cultivated with such ardour and success. I need hardly recall that the branch of mathemathics to which he had specially devoted himself was that most interesting and difficult one, the Theory of Numbers. The immense range of this subject, connected with and ramifying into so many others, is nowhere so well seen as in the series of Reports on the progress thereof,

* At page 25 he repeats:—"To communicate with England, Algeria, and other places, it would suffice to enclose the iron wire in an impermeable cloth, well tarred, and covered with sheet lead. In this way the electricity would operate with as much freedom as in subterranean lines, to which rivers would be no obstacles."

† Recurring to this subject, the author says, on page 16, Suppose the phrase to be pronounced by a stranger, you listen, and, as in a discourse one single sentence, when well understood, enables one to gather the sense of the whole, so in this case one single word well understood aids to a a comprehension of the whole sentence, usage and practice will do the rest.

‡ *We* think he would have made short work of it.

* "Telegrafo Elettro-Magnetico," Venezia, 1838, page 23.

† Since 1837 the following telegraphs have been proposed in which static electricity was to be employed:—By the Rev. H. Highton, in 1844 (patent No. 10,257 of 10th July); by Isham Baggs, in 1856 (patent No. 1,775 of 25th July), a most interesting document which will repay perusal in these days of multoplex and fast-speed apparatus; by C. F. Varley, in 1860 (patent No. 206 of 27th January); and by Wenckebach, a Dutch electrician, in 1873 (vide *Journal Télégraphique*, for March 25, 1873).

‡ Delivered by Professor Arthur Cayley, M.A., D.C.L., LL.D., F.R.S., Sadlerian Professor of Pure Mathematics in the University of Cambridge, at the Southport meeting, 19th Sept., 1883.

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brought up unfortunately only to the year 1865, contributed by him to the Reports of the Association; but it will still better appear when to these are united (as will be done in the collected works in course of publication by the Clarendon Press) his other mathematical writings, many of them containing his own further developments of theories referred to in the Reports. There have been recently or are being published many such collected editions—Abel Cauchy, Clifford, Gauss, Green, Jacobi, Lagrange, Maxwell, Riemann, Steiner. Among these the works of Henry Smith will occupy a worthy position.

More recently, General Sir Edward Sabine, K.C.B., for twenty-one years general secretary of the Association, and a trustee, President of the meeting at Belfast in the year 1853, and for many years treasurer and afterwards President of the Royal Society, has been taken from us, at an age exceeding the ordinary age of man. Born October, 1788, he entered the Royal Artillery in 1803, and commanded batteries at the seige of Fort Erie in 1814; made magnetic and other observations in Ross and Parry's North Polar Exploration in 1818-19, and in a series of other voyages. He contributed to the Association reports on Magnetic Forces in 1836-7-8, and about forty papers to the *Philosophical Transactions* originated, the system of Magnetic Observatories, and otherwise signally promoted the science of Terrestrial Magnetism.

There is yet a very great loss. Another late President and Trustee of the Association, one who has done for it so much, and has so often attended the meetings, whose presence among us at this meeting we might have hoped for—the President of the Royal Society, William Spottiswoode. It is unnecessary to say anything of his various merits; the place of his burial, the crowd of sorrowing friends who were present in the Abbey, bear witness to the esteem in which he was held.

I take the opportunity of mentioning the completion of a work promoted by the Association; the determination by Mr. James Glaisher, of the least factors of the numbers of the missing three out of the first nine million numbers. The sixth million is just finished.

I wish to speak to you to-night upon Mathematics. I am quite aware of the difficulty arising from the abstract nature of my subject; and if, as I fear, many or some of you, recalling the Presidential Addresses at former meetings—for instance, the *résumé* and survey which we had at York of the progress, during the half century of the lifetime of the Association, of a whole circle of sciences—Biology, Palæontology, Geology, Astronomy, Chemistry—so much more familiar to you, and in which there was so much to tell of the fairy tales of science; or at Southampton, the discourse of my friend who has in such kind terms introduced me to you, on the wondrous practical applications of science to electric lighting, telegraphy, the St. Gothard Tunnel, and the Suez Canal, gun cotton, and a host of other purposes, and with his grand concluding speculation on the conservation of solar energy; if, I say recalling these or any earlier Addresses, you should wish that you were now about to have, from a different President, a discourse on a different subject, I can very well sympathise with you in the feeling.

But be this as it may, I think it is more respectful to you that I should speak to you upon and do my best to interest you in the subject which has occupied me, and in which I am myself most interested. And in another point of view, I think it is right that the Address of a President should be on his own subject, and that different subjects should be thus brought in turn before the meetings. So much the worse, it may be, for a particular meeting; but the meeting is the individual, which on evolution principles must be sacrificed for the development of the race.

Mathematics connect themselves on the one side with common life and the physical sciences; on the other side with philosophy, in regard to our notions of space and time, and in the questions which have arisen as to the universality and necessity of the truths of mathematics, and the foundation of our knowledge of them. I would remark here that the connection (if it exists) of arithmetic and algebra with the notion of time is far less obvious than that of geometry with the notion of space.

As to the former side, I am not making before you a defence of mathematics, but if I were I should desire to do it in such manner as in the "Republic" Socrates was required to defend justice, quite irrespectively of the worldly advantages which may accompany a life of virtue and justice, and to show that, independently of all these, justice was a thing desirable in itself and for its own sake—*not* by speaking to you of the utility of mathematics in any of the questions of common life or of physical science. And still less would I thus defend mathematics before, I trust, a friendly audience, interested or willing to appreciate an interest in mathematics in itself and for its own sake. I would, on the contrary, rather consider the obligations of mathematics to these different subjects as the sources of mathematical theories now as remote from them, and in as different a region of thought—for instance, geometry from the measurement of land, or the Theory of Numbers from arithmetic—as a river at its mouth is from its mountain source.

On the other side, the general opinion has been and is that it is indeed by experience that we arrive at the truths of mathematics, but that experience is not their proper foundation; the mind itself contributes something. This is involved in the Platonic theory of reminiscence; looking at two things, trees or stones or anything else, which seem to us more or less equal, we arrive at the idea of equality; but we must have had this idea of equality before the time when first seeing the two things we were led to regard them as coming up more or less perfectly to this idea of equality; and the like as regards our idea of the beautiful, and in other cases.

The same view is expressed in the answer of Leibnitz, the *nisi intellectus ipse*, to the scholastic dictum, *nihil in intellectu quod non prius in sensu*; there is nothing in the intellect which was not first in sensation, except (said Leibnitz) the intellect itself. And so again in the "Critick of Pure Reason," Kant's view is that while there is no doubt but that all our cognition begins with experience, we are nevertheless in possession of cognitions *a priori*, independent, not of this or that experience, but absolutely so of all experience, and in particular that the axioms of mathematics furnish an example of such cognitions *a priori*. Kant holds further that space is no empirical conception which has been derived from external experiences, but that in order that sensations may be referred to something external, the representation of space must already lie at the foundation; and that the external experience is itself first only possible by this representation of space. And in like manner time is no empirical conception which can be deduced from an experience, but it is a necessary representation lying at the foundation of all intuitions.

And so in regard to mathematics, Sir W. R. Hamilton, in an introductory Lecture on Astronomy (1836), observes: "These purely mathematical sciences of algebra and geometry are sciences of the pure reason, deriving no weight and no assistance from experiment, and isolated or at least isolable from all outward and accidental phenomena. The idea of order with its subordinate ideas of number and figure, we must not indeed call innate ideas, if that phrase be defined to imply that all men must possess them with equal clearness and fulness; they are, however, ideas which seem to be so far born with us that the possession of them in any conceivable degree is only the development of our original powers, the unfolding of our proper humanity."

The general question of the ideas of space and time, the axioms and definitions of geometry, the axioms relating to number, and the nature of mathematical reasoning, are fully and ably discussed in Whewell's "Philosophy of the Inductive Sciences" (1840), which may be regarded as containing an exposition of the whole theory.

But it is maintained by John Stuart Mill that the truths of mathematics, in particular those of geometry, rest on experience; and as regards geometry, the same view is on very different grounds maintained by the mathematician Riemann.

It is not so easy as at first sight it appears to make out how far the views taken by Mill in his "System of Logic Ratiocinative and Inductive" (9th ed. 1879) are absolutely contradictory to those which have been spoken of; they profess to be so; there are most definite assertions (supported by argument), for instance, p. 253:—"It remains to inquire what is the ground of our belief in axioms, what is the evidence on which they rest? I answer, they are experimental truths, generalisations from experience. The proposition 'Two straight lines cannot enclose a space,' or, in other words, two straight lines which have once met cannot meet again, is an induction from the evidence of our senses." But I cannot help considering a previous argument (p. 259) as very materially modifying this absolute contradiction. After inquiring "Why are mathematics by almost all philosophers. . . . . considered to be independent of the evidence of experience and observation, and characterised as systems of necessary truth?" Mill proceeds (I quote the whole passage) as follows:—"The answer I conceive to be that this character of necessity ascribed to the truths of mathematics, and even (with some reservations to be hereafter made) the peculiar certainty ascribed to them, is a delusion, in order to sustain which it is necessary to suppose that those truths relate to and express the properties of purely imaginary objects. It is acknowledged that the conclusions of geometry are derived partly at least from the so-called definitions, and that these definitions are assumed to be correct representations, as far as they go, of the objects with which geometry is conversant. Now, we have pointed out that from a definition as such no proposition unless it be one concerning the meaning of a word can ever follow, and that what apparently follows from a definition, follows in reality from an implied assumption that there exists a real thing conformable thereto. This assumption in the case of the definitions of geometry is not strictly true; there exist no real things exactly conformable to the definitions. There exist no real points without magnitude, no lines without breadth, nor perfectly straight, no circles with all their radii exactly equal, nor squares with all their angles perfectly right. It will be said that the assumption does not extend to the actual but only to the possible existence of such things. I answer that according to every test we have of possibility they are not even possible. Their existence, so far as we can form any judgment, would seem to be inconsistent with the physical constitution of our planet at least, if not of the universal [*sic*]. To get rid of this difficulty, and at the same to save the credit of the supposed system of necessary truth, it is customary to say the points, lines, circles, and squares which are the subjects of geometry exist in our conceptions merely and are parts of our minds; which minds by working on their own materials construct an *a priori* science, the evidence of which is purely mental, and has nothing to do with outward experience. By howsoever high authority this doctrine has been sanctioned, it appears to me psychologically incorrect. The points, lines, and squares which anyone has in his mind are (as I apprehend) simply copies of the points, lines, and squares which he has known in his experience. Our idea of a point I apprehend to be simply our idea of the *minimum visibile*, the small portion of surface which we can see. We can reason about a line as if it had no breadth, because we have a power which we can exercise over the operations of our minds: the power, when a perception is present to our senses or a conception to our intellects, of *attending* to a part only of that perception or conception instead of the whole. But we cannot *conceive* a line without breadth: we can form no mental picture of such a line; all the lines which we have in our mind are lines possessing breadth. If any one doubt this, we may refer him to his own experience. I much question if any one who fancies that he can conceive of a mathematical line thinks so from the evidence of his own consciousness. I suspect it is rather because he supposes that unless such a perception be possible, mathematics could not exist as a science: a supposition which there will be no difficulty in showing to be groundless."

I think it may be at once conceded that the truths of geometry are truths precisely because they relate to and express the properties of what Mill calls "purely imaginary objects;" that these objects do not exist in Mill's sense, that they do not exist in nature, may also be granted; that they are "not even possible," if this means not possible in an existing nature, may also be granted. That we cannot "conceive" them depends on the meaning which we attach to the word conceive. I would myself say that the purely imaginary objects are the only realities, the ὄντως ὄντα, in regard to which the corresponding physical objects are as the shadows in the cave; and it is only by means of them that we are able to deny the existence of a corresponding physical object: if there is no conception of straightness, then it is meaningless to deny the existence of a perfectly straight line.

But at any rate the objects of geometrical truth are the so-called imaginary objects of Mill, and the truths of geometry are only true, and *a fortiori* are only necessarily true, in regard to these so-called imaginary objects; and these objects, points, lines, circles, &c., in the mathematical sense of the terms, have a likeness to and are represented more or less imperfectly, and from a geometer's point of view no matter how imperfectly, by corresponding physical points, lines, circles, &c. I shall have to return to geometry, and will then speak of Riemann, but I will first refer to another passage of the "Logic".

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Speaking of the truths of arithmetic Mill says (p. 297) that even here there is one hypothetical element: "In all propositions concerning numbers a condition is implied without which none of them would true, and that condition is an assumption which may be false. The condition is that 1 = 1: that all the numbers are numbers of the same or of equal units." Here at least the assumption may be absolutely true: one shilling = one shilling in purchasing power, although they may not be absolutely of the same weight and fineness: but it is hardly necessary; one coin + one coin = two coins, even if the one be a shilling and the other a half-crown. In fact, whatever difficulty be raisable as to geometry, it seems to me that no similar difficulty applies to arithmetic; mathematician or not, we have each of us, in its most abstract form, the idea of a number; we can each of us appreciate the truth of a proposition in regard to numbers: and we cannot but see that a truth in regard to numbers is something different in kind from an experimental truth generalised from experience. Compare, for instance, the proposition that the sun, having already risen so many times, will rise to-morrow, and the next day, and the day after that, and so on, and the proposition that even and odd numbers succeed each other alternately *ad infinitum*: the latter at least seems to have the characters of universality and necessity. Or, again, suppose a proposition observed to hold good for a long series of numbers, one thousand numbers, two thousand numbers, as the case may be: this is not only no proof, but it is absolutely no evidence, that the proposition is a true proposition, holding good for all numbers whatever; there are in the theory of numbers very remarkable instances of propositions observed to hold good for very long series of numbers, and which are nevertheless untrue.

I pass in review certain mathematical theories.

In arithmetic and algebra, or say in analysis, the numbers or magnitudes which we represent by symbols are in the first instance ordinary (that is, positive) numbers or magnitudes. We have also in analysis and in analytical geometry *negative* magnitudes; there has been in regard to these plenty of philosophical discussion, and I might refer to Kant's paper, "Ueber die negativen Grössen in die Weltweisheit" (1763), but the notion of a negative magnitude has become quite a familiar one, and has extended itself into common phraseology. I may remark that it is used in a very refined manner in bookkeeping by double entry.

But it is far otherwise with the notion which is really the fundamental one (and I cannot too strongly emphasise the assertion) underlying and pervading the whole of modern analysis and geometry, that of imaginary magnitude in analysis and of imaginary space (or space as a *locus in quo* of imaginary points and figures) in geometry: I use in each case the word imaginary as including real. This has not been, so far as I am aware, a subject of philosophical discussion or inquiry. As regards the older metaphysical writers, this would be quite accounted for by saying that they knew nothing, and had no call to know anything, about it: but at present, and considering the prominent position which the notion occupies—say even that the conclusion were that the notion belongs to mere technical mathematics, or has reference to nonenties in regard to which no science is possible, still it seems to me that (as a subject of philosophical discussion) the notion ought not to be thus ignored; it should at least be shown that there is a right to ignore it.

Although in logical order I should perhaps now speak of the notion just referred to, it will be convenient to speak first of some other quasi-geometical notions; those of more-than-three-dimensional space, and of non-Euclidian two and three dimensional space, and also of the generalised notion of distance. It is in connection with these that Riemann considered that our notion of space is founded on experience, or rather that it is only by experience that we know that our space is Euclidian space.

It is well known that Euclid's twelfth axiom, even in Playfair's form of it, has been considered as needing demonstration; and that Lobatschewsky constructed a perfectly consistent theory, wherein this axiom was assumed not to hold good, or say a system of non-Euclidian plane geometry. There is a like system of non-Euclidian solid geometry. My own view is that Euclid's twelfth axiom in Playfair's form of it does not need demonstration, but is part of our notion of space, of the physical space of our experience—the space, that is, which we become acquainted with by experience, but which is the representation lying at the foundation of all external experience. Riemann's view before referred to may, I think, be said to be that, having *in intellectu* a more general notion of space (in fact, a notion of non-Euclidian space), we learn by experience that space (the physical space of our experience) is, if not exactly, at least to the highest degree of approximation, Euclidian space.

But suppose the physical space of our experience to be thus only approximately Euclidian space, what is the consequence which follows? *Not* that the propositions of geometry are only approximately true, but that they remain absolutely true in regard to that Euclidian space which has been so long regarded as being the physical space of our experience.

It is interesting to consider two different ways in which, without any modification at all of our notion of space, we can arrive at a system of non-Euclidian (plane or two dimensional) geometry; and the doing so will, I think, throw some light on the whole question.

First, imagine the earth a perfectly smooth sphere; understand by a plane the surface of the earth, and by a line the apparently straight line (in fact, an arc of great circle) drawn on the surface; what experience would in the first instance teach would be Euclidian geometry; there would be intersecting lines which produced a few miles or so would seem to go on diverging; and apparently parallel lines which would exhibit no tendency to approach each other; and the inhabitants might very well conceive that they had by experience established the axiom that two straight lines cannot enclose a space, and the axiom as to parallel lines. A more extended experience and more accurate measurements would teach them that the axioms were each of them false; and that any two lines if produced far enough each way, would meet in two points; they would, in fact, arrive at a spherical geometry, accurately representing the properties of the two dimensional space of their experience. But their original Euclidian geometry would not the less be a true system, only it would apply to an ideal space, not the space of their experience.

Secondly, consider an ordinary, indefinitely extended plane; and let us modify only the notion of distance. We measure distance, say, by a yard measure or a foot rule, anything which is short enough to make the fractions of it of no consequence (in mathematical language by an infinitesimal element of length); imagine, then, the length of this rule constantly changing (as it might do by an alteration of temperature), but under the condition that its actual length shall depend only on its situation on the plane and on its direction, viz., if for a given situation and direction it has a certain length, then whenever it comes back to the same situation and direction it must have the same length. The distance along a given straight or curved line between any two points could then be measured in the ordinary manner with this rule, and would have a perfectly determinate value; it could be measured over and over again, and would always be the same; but of course it would be the distance, not in the ordinary acceptation of the term, but in quite a different acceptation. Or in a somewhat different way; if the rate of progress from a given point in a given direction be conceived as depending only on the configuration of the ground, and the distance along a given path between any two points thereof be measured by the time required for traversing it, then in this way also the distance would have a perfectly determinate value; but it would be a distance, not in the ordinary acceptation of the term, but in quite a different acceptation. And corresponding to the new notion of distance we should have a new, non-Euclidian system of plane geometry; all theorems involving the notion of distance would be altered.

We may proceed further. Suppose that as the rule moves away from a fixed central point of the plane it becomes shorter and shorter; if this shortening takes place with sufficient rapidity, it may very well be that a distance which in the ordinary sense of the word is finite will in the new sense be infinite; no number of repetitions of the length of the ever-shortening rule will be sufficient to cover it. There will be surrounding the central point a certain finite area such that (in the new acceptation of the term distance) each point of the boundary thereof will be at an infinite distance from the central point; the points outside this area you cannot by any means arrive at with your rule; they will form a *terra incognita*, or rather an unknowable land—in mathematical language, an imaginary or impossible space—and the plane space of the theory will be that within the finite area; that is, it will be finite instead of infinite.

We thus with a proper law of shortening arrive at a system of non-Euclidian geometry which is essentially that of Lobatschewsky. But in so obtaining it we put out of sight its relation to spherical geometry—the three geometries (spherical, Euclidian, and Lobatschewsky's) should be regarded as members of a system—viz., they are the geometries of a plane (two-dimensional) space of constant positive curvature, zero curvature, and constant negative curvature respectively; or again, they are the plane geometries corresponding to three different notions of distance; in this point of view they are Klein's elliptic, parabolic, and hyperbolic geometries respectively.

Next as regards solid geometry: we can by a modification of the notion of distance (such as has just been explained in regard to Lobatschewsky's system) pass from our present system to a non-Euclidian system; for the other mode of passing to a non-Euclidian system it would be necessary to regard our space as a flat three-dimensional space existing in a space of four dimensions (*i.e.*, as the analogue of a plane existing in ordinary space); and to substitute for such flat three-dimensional space a curved three-dimensional space, say of constant positive or negative curvature. In regarding the physical space of our experience as possibly non-Euclidian, Riemann's idea seems to be that of modifying the notion of distance, not that of treating it as a locus in four-dimensional space.

I have just come to speak of four-dimensional space. What meaning do we attach to it? Or can we attach to it any meaning? It may be at once admitted that we cannot conceive of a fourth dimension of space; that space as we conceive of it, and the physical space of our experience, are alike three-dimensional; but we can, I think, conceive of space as being two or even one-dimensional; we can imagine rational beings living in a one-dimensional space (a line) or in a two-dimensional space (a surface) and conceiving of space accordingly, and to whom, therefore, a two-dimensional space, or (as the case may be) a three-dimensional space would be as inconceivable as a four-dimensional space is to us. And very curious speculative questions arise. Suppose the one-dimensional space a right line, and that it afterwards becomes a curved line, would there be any indication of the change? Or, if originally a curved line, would there be anything to suggest to them that it was not a right line? Probably not, for a one-dimensional geometry hardly exists. But let the space be two-dimensional, and imagine it originally a plane, and afterwards bent (converted, that is, into some form of developable surface) or converted into a curved surface, or imagine it originally a developable or curved surface. In the former case there should be an indication of the change, for the geometry originally applicable to the space of their experience (our own Euclidian geometry) would cease to be applicable; but the change could not be apprehended by them as a bending or deformation of the plane, for this would imply the notion of a three-dimensional space in which this bending or deformation could take place. In the latter case their geometry would be that appropriate to the developable or curved surface which is their space: viz., this would be their Euclidian geometry; would they ever have arrived at our own more simple system? But take the case where the two-dimensional space is a plane, and imagine the beings of such a space familiar with our own Euclidian plane geometry; if, a third dimension being still inconceivable by them, they were by their geometry or otherwise led to the notion of it, there would be nothing to prevent them from forming a science such as our own science of three-dimensional geometry.

Evidently all the foregoing questions present themselves in regard to ourselves, and to three-dimensional space as we conceive of it, and as the physical space of our experience. And I need hardly say that the first step is the difficulty, and that granting a fourth dimension we may assume as many more dimensions as we please. But whatever answer be given to them, we have, as a branch of mathematics, potentially, if not actually, an analytical geometry of n-dimensional space. I shall have to speak again upon this.

Coming now to the fundamental notion already referred to, that of imaginary magnitude in analysis and imaginary space in geometry: I connect this with two great discoveries in mathematics made in the first half of the seventeenth century, Harriot's representation of an equation in the form $f(x) = 0$, and the consequent notion of the roots of an equation as derived from the linear factors of $f(x)$, (Harriot, 1560—1621: his "Algebra," published after his death, has the date 1631), and Descartes' "method of co-ordinates," as given in the "Géometrie," forming a short supplement to his "Traité de la Méthode, &c." (Leyden, 1637).

I show how by these we are led to the notion of imaginary points in

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geometry: for instance, we arrive at the theorem that a straight line and a circle in the same plane intersect *always* in two points, real or imaginary.

It is in this way that we are lead analytically to the notion of imaginary points in geometry. The conclusion as to the two points of intersection cannot be contradicted by experience. Take a sheet of paper and draw on it the straight line and circle, and try. But you might say, or at least be strongly tempted to say, that it is meaningless. The question of course arises, What is the meaning of an imaginary point? and further, In what manner can the notion be arrived at geometrically?

There is a well-known construction in perspective for drawing lines through the intersection of two lines, which are so nearly parallel as not to meet within the limits of the sheet of paper. You have two given lines which do not meet, and you draw a third line, which, when the lines are all of them produced, is found to pass through the intersection of the given lines. If instead of lines we have two circular arcs not meeting each other, then we can, by means of these arcs, construct a line; and if on completing the circles it is found that the circles intersect each other in two real points, then it will be found that the line passes through these two points; if the circles appear not to intersect, then the line will appear not to intersect either of the circles. But the geometrical construction being in each case the same, then we say that in the second case also the line passes through the two intersections of the circles.

Of course it may be said in reply that the conclusion is a very natural one, provided we assume the existence of imaginary points; and that, this assumption not being made, then, if the circles do not intersect, it is meaningless to assert that the line passes through their points of intersection. The difficulty is not got over by the analytical method before referred to, for this introduces difficulties of its own. Is there in a plane a point the co-ordinates of which have given imaginary values? As a matter of fact, we do consider in plane geometry imaginary points introduced into the theory analytically or geometrically as above.

The like considerations apply to solid geometry, and we thus arrive at the notion of imaginary space as a *locus in quo* of imaginary points and figures.

I have used the word imaginary rather than complex, and I repeat that the word has been used as including real. But, this once understood, the word becomes in many cases superfluous, and the use of it would even be misleading. Thus, "a problem has so many solutions;" this means so many imaginary (including real) solutions. But if it were said that the problem had "so many imaginary solutions," the word "imaginary" would here be understood to be used in opposition to real. I give this explanation the better to point out how wide the application of the notion of the imaginary is, viz. (unless expressly or by implication excluded), it is a notion implied and presupposed in all the conclusions of modern analysis and geometry. It is, as I have said, the fundamental notion underlying and pervading the whole of these branches of mathematical science.

I consider the question of the geometrical representation of an imaginary variable. We represent the imaginary variable $x + iy$ by means of a point in a plane, the co-ordinates of which are (x, y). This idea, due to Gauss, dates from about the year 1831. We thus picture to ourselves the succession of values of the imaginary variable $x + iy$ by means of the motion of the representative point; for instance, the succession of values corresponding to the motion of the point along a closed curve to its original position. The value $X + iY$ of the function can of course be represented by means of a point (taken for greater convenience in a different plane), the co-ordinates of which are X, Y.

We may consider in general two points, moving each in its own plane, so that the position of one of them determines the position of the other, and consequently the motion of the one determines the motion of the other: for instance, the two points may be the tracing-point and the pencil of a pentagraph. You may with the first point draw any figure you please, there will be a corresponding figure drawn by the second point: for a good pentagraph, a copy on a different scale (it may be); for a badly-adjusted pentagraph, a distorted copy; but the one figure will always be a sort of copy of the first, so that to each point of the one figure there will correspond a point in the other figure.

In the case above referred to, where one point represents the value $x + iy$ of the imaginary variable and the other the value $X + iY$ of some function $\phi(x + iy)$ of that variable, there is a remarkable relation between the two figures: this is the relation of orthomorphic projection, the same which presents itself between a portion of the earth's surface, and the representation thereof by a map on the stereographic projection or on Mercator's projection—viz. any indefinitely small area of the one figure is represented in the other figure by an indefinitely small area of the same shape. There will possibly be for different parts of the figure great variations of scale, but the shape will be unaltered; if for the one area the boundary is a circle, then for the other area the boundary will be a circle; if for one it is an equilateral triangle, then for the other it will be an equilateral triangle.

I have been speaking of an imaginary variable $(x + iy)$, and of a function $\phi(x + iy) = X + iY$ of that variable, but the theory may equally well be stated in regard to a plane curve; in fact, the $x + iy$ and the $X + iY$ are two imaginary variables connected by an equation. Say their values are u, and v, connected by an equation $F(u, v) = 0$; then, regarding u, v as the co-ordinates of a point *in plano*, this will be a point on the curve represented by the equation. The curve, in the widest sense of the expression, is the whole series of points, real or imaginary, the co-ordinates of which satisfy the equation, and these are exhibited by the foregoing corresponding figures in two planes; but in the ordinary sense the curve is the series of real points, with co-ordinates u, v, which satisfy the equation.

In geometry it is the curve, whether defined by means of its equation, or in any other manner, which is the subject for contemplation and study. But we also use the curve as a representation of its equation—that is, of the relation existing between two magnitudes x, y, which are taken as the co-ordinates of a point on the curve. Such employment of a curve for all sorts of purposes—the fluctuations of the barometer, the Cambridge boat races, or the Funds—is familiar to most of you. It is in like manner convenient in analysis, for exhibiting the relations between any three magnitudes x, y, z, to regard them as the co-ordinates of a point in space; and, on the like ground, we should at least wish to regard any four or more magnitudes as the co-ordinates of a point in space of a corresponding number of dimensions. Starting with the hypothesis of such a space, and of points therein each determined by means of its co-ordinates, it is found possible to establish a system of n-dimensional geometry analogous in every respect to our two and three-dimensional geometries, and to a very considerable extent serving to exhibit the relations of the variables.

It is to be borne in mind that the space, whatever its dimensionality may be, must always be regarded as an imaginary or complex space such as the two or three-dimensional space of ordinary geometry; the advantages of the representation would otherwise altogether fail to be obtained.

I omit some further geometrical developments, and also all that I have written in regard to the connection of mathematics with the notion of time.

I said that I would speak to you, not of the utility of the mathematics in any of the questions of common life or of physical science, but rather of the obligations of mathematics to these different subjects. The consideration which this presents itself is in a great measure that of the history of the development of the different branches of mathematical science in connection with the older physical sciences astronomy and mechanics; the mathematical theory is in the first instance suggested by some such question of common life or of physical science, is pursued and studied quite independently thereof, and perhaps after a long interval comes in contact with it, or with quite a different question. Geometry and algebra must, I think, be considered as each of them originating in connection with objects or questions of common life—geometry, notwithstanding its name, hardly in the measurement of land, but rather from the contemplation of such forms as the straight line, the circle, the ball, the top (or sugar-loaf): the Greek geometers appropriated for the geometrical forms corresponding to the last two of these, the words σφαῖρα and κῶνος our cone and sphere, and they extended the word cone to mean the complete figure obtained by producing the straight lines of the surface both ways indefinitely. And so algebra would seem to have arisen from the sort of easy puzzles in regard to numbers which may be made, either in the picturesque forms of the Bija-ganita with its maiden with the beautiful locks, and its swarms of bees amid the fragrant blossoms, and the one queen-bee left humming around the lotus flower, or in the more prosaic form in which a student has presented to him in a modern text-book a problem leading to a simple equation.

The Greek geometry may be regarded as beginning with Plato (B.C. 430—347): the notions of geometrical analysis, loci, and the conic sections are attributed to him, and there are in his Dialogues many very interesting allusions to mathematical questions: in particular the passage in the "Theætetus," where he affirms the incommensurability of the sides of certain squares. But the earliest extant writings are those of Euclid (B.C. 285): there is hardly anything in mathematics more beautiful than his wondrous fifth book; and he has also in the seventh, eighth, ninth and tenth books fully and ably developed the first principles of the Theory of Numbers, including the theory of incommensurables. We have next Apollonius (about B.C. 217), and Archimedes (B.C. 287—212), both geometers of the highest merit, and the latter of them the founder of the science of statics (including therein hydrostatics); his dictum about the lever, his "Εὕρηκα" and the story of the defence of Syracuse, are well known. Following these we have a worthy series of names, including the astronomers Hipparchus (B.C. 150) and Ptolemy (A.D. 125), and ending, say, with Pappus (A.D. 400), but continued by their Arabian commentators, and the Italian and other European geometers of the sixteenth century and later, who pursued the Greek geometry.

The Greek arithmetic was, from the want of a proper notation, singularly cumbrous and difficult; and it was for astronomical purposes superseded by the sexagesimal arithmetic, attributed to Ptolemy, but probably known before his time. The use of the present so-called Arabic figures became general among Arabian writers on arithmetic and astronomy about the middle of the tenth century, but was not introduced into Europe until about two centuries later. Algebra among the Greeks is represented almost exclusively by the treatise of Diophantus (A.D. 150), in fact a work on the Theory of Numbers containing questions relating to square and cube numbers, and other properties of numbers, with their solutions; this has no historical connection with the later algebra, introduced into Italy from the East by Leonardi Bonacci of Pisa (A.D. 1202—1208) and successfully cultivated in the fifteenth and sixteenth centuries by Lucas Paciolus, or De Burgo, Tartaglia, Cardan, and Ferrari. Later on, we have Vieta (1540—1603), Harriot, already referred to, Wallis, and others.

Astronomy is of course intimately connected with geometry; the most simple facts of observation of the heavenly bodies can only be *stated* in geometrical language: for instance, that the stars describe circles about the pole-star, or that the different positions of the sun among the fixed stars in the course of the year form a circle. For astronomical calculations it was found necessary to determine the arc of a circle by means of its chord: the notion is as old as Hipparchus, a work of whom is referred to as consisting of twelve books on the chords of circular arcs; we have (A.D. 125) Ptolemy's "Almagest," the first book of which contains a table of arcs and chords with the method of construction: and among other theorems on the subject he gives there the theorem afterwards inserted in Euclid (Book VI. Prop. D) relating to the rectangle contained by the diagonals of a quadrilateral inscribed in a circle. The Arabians made the improvement of using in place of the chord of an arc the sine, or half chord of double the arc; and so brought the theory into the form in which it is used in modern trigonometry: the before-mentioned theorem of Ptolemy, or rather a particular case of it, translated into the notation of sines gives the expression for the sine of the sum of two arcs in terms of the sines and cosines of the component arcs; and it is thus the fundamental theorem on the subject. We have in the fifteenth and sixteenth centuries a series of mathematicians who with wonderful enthusiasm and perseverance calculated tables of the trigonometrical or circular functions, Purbach, Müller or Regiomontanus, Copernicus, Reinhold, Maurolycus, Vieta, and many others; the tabulations of the functions tangent and secant are due to Reinhold and Maurolycus respectively.

Logarithms were invented, not exclusively with reference to the calculation of trigonometrical tables, but in order to facilitate numerical calculations generally; the invention is due to John Napier, of Merchiston, who died in 1618, at 67 years of age; the notion was based upon refined mathematical reasoning on the comparison of the spaces described by two points, the one moving with a uniform velocity, the other with a velocity varying according to a given law. It is to be observed that Napier's logarithms

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were nearly but not exactly those which are now called (sometimes Napierian, but more usually) hyperbolic logarithms—those to the base e; and that the change to the base 10 (the great step by which the invention was perfected for the object in view) was indicated by Napier but actually made by Henry Briggs, afterwards Savilian Professor at Oxford (d. 1630). But it is the hyperbolic logarithm which is mathematically important. The direct function e^x or exp. x, which has for its inverse the hyperbolic logarithm, presented itself, but not in a prominent way. Tables were calculated of the logarithms of numbers, and of those of the trigonometrical functions.

The circular functions and the logarithm were thus invented each for a practical purpose, separately and without any proper connection with each other. The functions are connected through the theory of imaginaries and form together a group of the utmost importance throughout mathematics; but this is mathematical theory; the obligation of mathematics is for the discovery of the functions.

Forms of spirals presented themselves in Greek architecture, and the curves were considered mathematically by Archimedes; the Greek geometers invented some other curves, more or less interesting, but recondite enough in their origin. A curve which might have presented itself to anybody, that described by a point in the circumference of a rolling carriage-wheel, was first noticed by Mersenne in 1615, and is the curve afterwards considered by Roberval, Pascal, and others under the name of the Roulette, otherwise the Cycloid. Pascal (1623-1662) wrote at the age of seventeen his "Essais pour les Coniques" in seven short pages, full of new views on these curves, and in which he gives, in a paragraph of eight lines, his theorem of the inscribed hexagon.

Kepler (1571-1630) by his empirical determination of the laws of planetary motion, brought into connection with astronomy one of the forms of conic, the ellipse, and established a foundation for the theory of gravitation. Contemporary with him, for most of his life, we have Galileo (1564-1642), the founder of the science of dynamics; and closely following upon Galileo we have Isaac Newton (1643-1727): the "Philosophiæ Naturalis Principia Mathematica" known as the "Principia" was first published in 1687.

The physical, mechanical, or dynamical questions which presented themselves before the publication of the "Principia" were of no particular mathematical difficulty, but it is quite otherwise with the crowd of interesting questions arising out of the theory of gravitation, which, in becoming the subject of mathematical investigation, have contributed very much to the advance of mathematics. We have the problem of two bodies, or what is the same thing, that of the motion of a particle about a fixed centre of force, for any law of force: we have also the (mathematically very interesting) problem of the motion of a body attracted to two or more fixed centres of force; after this, next preceding that of the actual solar system—the problem of three bodies; this has ever been and is far beyond the power of mathematics, and it is in the lunar and planetary theories replaced by what is mathematically a different problem, that of the motion of a body under the action of a principal central force and a disturbing force; or (in one mode of treatment) by the problem of disturbed elliptic motion. I would remark that we have here an instance in which an astronomical fact, the observed slow variation of the orbit of a planet, has directly suggested a mathematical method, applied to other dynamical problems, which is the basis of very extensive modern investigations in regard to systems of differential equations. Again, immediately arising out of the theory of gravitation we have the problem of finding the attraction of a solid body of any given form upon a particle, solved by Newton in the case of a homogenous sphere, but which is far more difficult in the next succeeding cases of the spheroid of revolution (very ably treated by Maclaurin) and of the ellipsoid of three unequal axes: there is perhaps no problem of mathematics which has been treated by as great a variety of methods, or has given rise to so much interesting investigation as this last problem of the attraction of an ellipsoid upon an interior or exterior point. It was a dynamical problem, that of vibrating strings, by which Lagrange was led to the theory of the representation of a function as the sum of a series of multiple sines and cosines; and connected with this we have the expansions in terms of Legendre's functions P_n, suggested to him by the question just referred to of the attraction of an ellipsoid: the subsequent investigations of Laplace on the attractions of bodies differing slightly from the sphere led to the functions of two variables called Laplace's functions. I have been speaking of ellipsoids, but the general theory is that of attractions, which has become a very wide branch of modern mathematics; associated with it we have in particular the names of Gauss, Lejeune-Dirichlet, and Green; and I must not omit to mention that the theory is now one relating to n-dimensional space. Another great problem of celestial mechanics, that of the motion of the earth about its centre of gravity, in the most simple case, that of a body not acted upon by any forces, is a very interesting one in the mathematical point of view.

I may mention a few other instances where a practical or physical question has connected itself with the development of mathematical theory. I have spoken of two map projections—the stereographic, dating from Ptolemy, and Mercator's projection, invented by Edward Wright about the year 1600. Each of these, as a particular case of the orthomorphic projection, belongs to the theory of the geometrical representation of an imaginary variable. I have spoken also of perspective, and (in an omitted paragraph) of the representation of solid figures employed in Monge's descriptive geometry. Monge, it is well known, is the author of the geometrical theory of the curvature of surfaces and of curves of curvature. He was led to this theory by a problem of earthwork—from a given area, covered with earth of uniform thickness, to carry the earth and distribute it over an equal given area with the least amount of cartage. For the solution of the corresponding problem in solid geometry he had to consider the intersecting normals of a surface, and so arrived at the curves of curvature. (See his "Mémoire sur les Déblais et les Remblais," Mem. de l'Acad., 1781.) The normals of a surface are, again, a particular case of a doubly infinite system of lines, and are so connected with the modern theories of congruences and complexes.

The undulatory theory of light led to Fresnel's wave-surface, a surface of the fourth order, by far the most interesting one which had then presented itself. A geometrical property of this surface, that of having tangent planes each touching it along a plane curve (in fact, a circle), gave to Sir W. R. Hamilton the theory of conical refraction. The wave-surface is now regarded in geometry as a particular case of Kummer's quartic surface, with sixteen conical points and sixteen singular tangent planes.

My imperfect acquaintance, as well with the mathematics as the physics, prevents me from speaking of the benefits which the theory of Partial Differential Equations has received from the hydrodynamical theory of vortex motion, and from the great physical theories of electricity, magnetism, and energy.

It is difficult to give an idea of the vast extent of modern mathematics. This word "extent" is not the right one. I mean extent crowded with beautiful detail—not an extent of mere uniformity such as an objectless plain, but of a tract of beautiful country seen at first in the distance, but which will bear to be rambled through and studied in every detail of hillside and valley, stream, rock, wood, and flower. But, as for anything else, so for a mathematical theory—beauty can be perceived, but not explained. As for mere extent I might illustrate this by speaking of the dates at which some of the great extensions have been made in several branches of mathematical science. And, in fact, in the address as written, I speak at considerable length of the extensions in geometry since the time of Descartes, and in other specified subjects since the commencement of the century. These subjects are the general theory of the function of an imaginary variable; the leading known functions, viz., the elliptic and single theta-functions, and the Abelian and multiple theta-functions; the theory of equations; and the theory of numbers. I refer also to some theories outside of ordinary mathematics; the multiple algebra, or linear associative algebra of the late Benjamin Pierce; the theory of Argaad Warren and Peacock of imaginaries in plane geometry, Sir W. R. Hamilton's quaternions, Clifford's theory of biquaternions, and the theories developed in Grassmann's "Ausdehnungslehre," with recent extensions thereof to non-Euclidian space by Mr. Homersham Cox; also Boole's "Mathematical Logic," and a work connected with logic, but which is primarily mathematical, and of the highest importance; Schubert's Abzählende Geometrie (1878). And I remark that all this in regard to theories outside of ordinary mathematics is still on the text of the vast extent of modern mathematics.

In conclusion I would say that mathematics has steadily advanced from the time of the Greek geometers. Nothing is lost or wasted; the achievements of Euclid, Archimedes, and Appolonius are as admirable now as they were in their own days. Descartes' method of co-ordinates is a possession for ever. But mathematics have never been cultivated more zealously and diligently, or with greater success, than in this century—in the last half of it, or at the present time: the advances made have been enormous, the actual field is boundless, the future full of hope. In regard to pure mathematics we may most confidently say:—

Yet I doubt not through the ages one increasing purpose runs,
And the thoughts of men are widened with the process of the suns.

TELEGRAPH ENTERPRISE AND DEEP SEA RESEARCH.

Under this heading *The Times* of the 20th inst. has the following:—

"Of late years, and notably since the voyage of the 'Challenger,' much attention has been devoted to deep sea investigation from a purely scientific point of view, and expeditions have been fitted out for this purpose from time to time by various Governments. These expeditions have all yielded a rich harvest of results, and in several countries they have become a part of the permanent marine establishment—as, for instance, in America, where the 'Albatross' has been built and equipped especially for this purpose; and in Italy, where her spirited hydrographer, Captain Magnaghi, in conjunction with Professor Giglioli, of Florence, every year explores some portion of the deeper waters of the Mediterranean. Since the return of the 'Challenger' but little has been done in this direction by our own Government; but though the country, as represented by its Government, may have done little, its credit has been amply sustained by the private enterprise of its telegraph engineers.

"The experience which has now been gained by the extension of cable communication to all corners of the globe has shown that the more carefully the route has been surveyed as regards not only the depth, but also the nature of the bottom, the greater is the likelihood that the cable will be laid successfully and will remain undamaged. It is evident that in the preparation of such a minute survey of a part of the ocean, much information valuable to science must be collected, and with proper precautions might be preserved and utilised.

"In order that the work done on board a telegraph ship for a purely commercial purpose may be made useful for science, means must be found for harvesting these results without affecting or interfering with the commercial character of the enterprise. With the view of carrying this out on board the ships of the India Rubber, Gutta Percha, and Telegraph Works Company, Mr. J. Y. Buchanan, who was a member of the scientific staff of the 'Challenger' expedition, has been invited to accompany the expedition which sailed yesterday from the Thames to survey the route and lay the cables connecting Cadiz and the Canary Islands, and these islands with Senegal, on the West Coast of Africa (*vide Electrician*, Sept. 15).

"Even on antiquarian grounds the survey of a part of the sea supposed to cover the site of the lost 'Atlantis' would be of great interest. This interest is much increased by recent experience during the laying of the cable from Lisbon to Madeira. The route had been carefully sounded, and the cable was being paid over into what was believed to be close on 2,000 fathoms, when it suddenly parted. Soundings taken immediately revealed the existence of a bank with no more than 110 fathoms of water on it, which had been missed while surveying the route. Again, quite recently —indeed within the last few weeks—the French exploring vessel 'Talisman,' which has been investigating this part of the ocean with a numerous scientific staff, under the direction of the veteran Milne-Edwards, discovered another bank to the southward of the 'Seine Bank' above-mentioned, with as little as 70 fathoms on it. This bank was found to be about 30 miles long from east to west, and six miles broad from north to south. The French Government has, with great promptitude and courtesy, supplied the company with the 'Talisman' soundings, and an important part of the work of the two cable ships which will be engaged in this service will be to thoroughly survey this bank and trace its connections, if any exist."

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ELECTRICAL UNITS.*

APPENDIX II.

List of works on Earth Currents, compiled by Alfred J. Frost, Librarian Soc. Tel. Engineers:—

1753 CANTON. Aurora Borealis, Observations of Electrical Signs Occasioned by. (*Phil. Trans.*, p. 350. 1753.)

1817 STARK, HERR (Augsburg). Observed that Volta's electrometer and the magnetic needle were almost constantly in motion during Aurora. (*Phil. Mag.* 1817?)

1831 FOX, R. W. On the Variable Intensity of Terrestrial Magnetism and the Influence of the Aurora Borealis upon it. (*Phil. Trans.*, p. 199. 1831.)

1831 FOX, R. W. Notice of Some Experiments on Subterranean Electricity made in Penzance Mine, near Falmouth. (*Trans. Royal Cornwall Polytechnic Society.* 1831 or 1832?) Falmouth.

1833 BACHE, A. D. Observations on the Disturbance in the Direction of the Magnetic Needle during the Aurora of 1833. (*Jour. Franklin Institute.* 1833.) Philadelphia.

1835 BACHE, A. D. Note of the Effect upon the Magnetic Needle of the Aurora visible at Philadelphia, 17th May, 1833. (*Jour. Franklin Institute.* July, 1835.) Philadelphia.

1843 LOOMIS, E. On Certain Storms in the United States, and in Europe and America. 1843-46-60.

1849 BARLOW, W. H. On the Spontaneous Electrical Currents observed in the Wires of the Electric Telegraph. Read May 25th, 1843. (*Phil. Trans.*, 1849, p. 61).

1850 LOOMIS, E. Experiments on the Electricity of a Plate of Zinc Buried in the Earth. (*Amer. Jour. Science*, Second Series, Vol. IX. 1850.) Newhaven.

1851 BROWN, J. A. On the Combined Motion of the Magnetic Needle, and on the Aurora Borealis. (*Proc. Royal Soc. of Edinburgh*, II., No. 39.)

1853 SABINE, GENERAL ED. The Bakerian Lecture. On the Influence of the Moon on the Magnetic Declination at Toronto, St. Helena, and Hobarton. (*Phil. Trans.* 1853.)

1855 HANSTEEN, CHRISTOPHER. Sur les Aurores Boréales et sur l'Inclinaison Magnétique à Bruxelles. (Ext. Tome XXI., No. 5, *des Bulletins de l'Acad. Brux.* 1855.) Bruxelles.

1861 LAMONT, DR. Letter to Astronomer Royal on Earth Currents. (*Phil. Mag.*, XXII., 1861, p. 438.)

1861 LLOYD, HUMPHREY. On Earth Currents and their Connection with the Phenomena of Terrestrial Magnetism. (*Proc. Roy. Irish Acad.*, November 11th, 1861, p. 318.) Dublin.

1861 LLOYD, REV. H. On Earth Currents. Read November 11th and 30th, 1861. (*Phil. Trans.*, 1861, p. 115.)

1861 STEWART, BALFOUR. On the Great Magnetic Disturbance which extended from August 28th to September 7th, 1859. (*Phil. Trans.*, Vol. CLI., p. 423.)

1861 WALKER, C. V. On Magnetic Storms and Earth Currents. Abstract. 8vo., 7 pp. (*Proc. Roy. Soc.*, February 14th, 1861.)

1861 WALKER, C. V. On Magnetic Storms and Earth Currents. (*Phil. Trans.*, Vol. CLI., p. 89. 1861.)

1862 JOULE, J. P. On the Probable Cause of Electrical Storms. (*Proc. Lit. and Phil. Soc. of Manchester*, 1862, and *Phil. Mag.*, XXIII., 1862.)

1862 LLOYD, H. On Earth Currents and their Connection with the Diurnal Changes of the Horizontal-Magnetic Needle. (*Proc. Roy. Irish Acad.*, Vol. XXIV. 1862.) Dublin.

1862 LLOYD, H. On Earth Currents in Connection with Magnetic Disturbances. (*Proc. Roy. Irish Acad.*, April 28th, 1862, p. 392.) Dublin.

1862 LLOYD, H. On the Probable Causes of the Earth Currents. (*Proc. Roy. Irish Acad.*, June 23rd, 1862, p. 442.) Dublin.

1862 STEWART, BALFOUR. On the Nature of the Forces Concerned in Producing the Greater Magnetic Disturbances. (*Phil. Trans.*, Vol. CLII., p. 621. 1862.)

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1881 ADAMS, A. J. S. Earth Currents, with Diagrams. Second Paper. (*Jour. Soc. Tel. Eng.* Vol. X., p. 34. 1881.)—Discussion by Adams, Professor W. G., F.R.S.; Whipple, G. M.; Wollaston, C.; Perry, Professor J.; Varley, C. F.; Ellis, W.; Banker, S. M.; Smith, W.; Graves, E.; Spagnoletti, C. E.; Winter, G. K.; Ayrton, Professor W. E.

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1883 WALKER, E. O. Magnetic Storm in India. (*Jour. Soc. Tel. Eng.*, February, 1883.)

DIRECT SPANISH TELEGRAPH COMPANY, LIMITED.

Report of the directors for the half year ended 30th June, 1883, to be presented at the general meeting of shareholders, to be held on Friday, 28th September, 1883. The accounts for the half year ended 30th June, 1883, show a balance to the credit of profit and loss of £6,642 17s. 1d. The receipts may be considered satisfactory in view of the fact that the Bilbao cable was interrupted from the 14th January to the 23rd February, and again from the 9th March to the 2nd April. The directors were authorised by the shareholders at an extraordinary general meeting, held on the 27th July last, to lay a duplicate cable between England and Spain, and the carrying out of this authority will have their best consideration when the proper time comes. The interruption of the Bilbao cable, which took place on 6th August, was promptly repaired, and the cable reopened to traffic on the 27th August. It has since continued in good working order. The Marseilles-Barcelona cable remained in perfect working order throughout the half year, and continues so. The opening of the special wire between London and Falmouth, by means of which direct communication with Spain is maintained from the Company's office in Leadenhall-street, took place on the 1st January last. This arrangement has proved successful, and the directors believe that a further development of the traffic will result from it. After paying the dividend on the preference shares, £3,000, and putting aside £200 to the reduction of preliminary expenses account, there remains a balance of £3,442 17s. 1d., which, looking to the repairs of the interruption of 6th August, it is proposed to carry to the reserve fund, that fund having been reduced to £820 18s. 11d., after providing for the repairs of the Bilbao cable in January, February and March last. The dividend warrants on the preference shares will be issued as soon as remittances from Spain for the balance of the telegraph accounts to 30th June last are received.

NUMBERS OF "THE ELECTRICIAN" OUT OF PRINT.—The following numbers of *The Electrician* are out of print, and cannot be supplied at the office, viz.:—Vol. 1, Nos. 3, 9, 19; Vol. 7, Nos. 8, 10, 12 to 18, 20, 21, 24 to 26; Vol. 8, 1, 3, 6 to 12, 15 to 26; Vol. 9, Nos. 2, 4, 24, 25; Vol. 10, No. 13.

COMPANIES' SHARE LIST.

TELEGRAPHS.

COMPANIES.	CLOSING PRICES SEPT. 19.	BUSINESS DONE WEEK ENDING SEPT. 19. Highest.	Lowest.
Anglo American	47½, 48	48	47½
Do. Preferred	79½, 80	80	79½
Do. Deferred	17, 17½	17½	17½
Brazil Submarine	11¾, 11⅞	11⅞	11 11-16
Cuba	10½, 11	10¾	—
Do. Preference	17, 18	17¼	—
Direct Spanish	5¼, 5¾	—	—
Do. Preference	15¾, 16¼	16¼	16
Direct United States Cable	12¼, 13	12¾	12½
Eastern Telegraph	10 11-16, 10 13-16	10 13-16	10¾
Do. 6 per Cent. Preference	12¾, 13¼	13¼	13 1-16
Do. 5 per Cent. Debentures, 1899	103, 107	103½	—
Eastern Extension	11 3-16, 11 5-16	11¼	11 3-16
German Union	9¾, 10¼	10 13-16	10½
Globe Telegraph and Trust Company	7½, 7⅝	7⅝	7 9-16
Do. Preference	12¾, 13	13	12 13-16
Great Northern	12¾, 13	12⅞	12 13-16
Indo-European	31, 32	—	—
Mediterranean Extension	1½, 2	—	—
Do. Preference	2, 4	—	—
Reuter's	8¾, 9¼	9	—
Submarine	220, 230	221	222
West India and Panama	¾, 1	⅞	—
Do. 1st Preference	6½, 6⅞	6⅞	—
Western Brazilian	5 13-16, 5 15-16	5 15-16	—
West. Union 7 per Cent. 1st Mortgage	122, 124	—	—
Do. 6 per Cent. Sterling Bonds	100, 103	—	—

TELEPHONES.

Consol. Telephone and Maintenance	5-16, 7-16	—	—
Oriental	5-16, 7-16	—	—
United Telephone	8⅝, 8⅞	9⅛	8⅞

ELECTRIC LIGHT.

Anglo-American Brush Lgt. (£7 paid)	2¼, 2½	2⅝	2½
Do. (fully paid)	5¾, 6¼	—	—
Hammond Light	⅞, 1⅛	15-16	⅞
Eastern Electric (£4 paid)	—, —	—	—
Swan	1⅞, 2¼	2	1 13-16
Maxim-Weston	1-16 3-16	—	—

MISCELLANEOUS.

Telegraph Construction	33, 34	33½	33
India Rubber, Gutta Percha, and Telegraph Works	29¾, 30½	30⅛	30

CITY and GUILDS of LONDON INSTITUTE.

TECHNICAL COLLEGE, FINSBURY.

EVENING DEPARTMENT for Apprentices, Journeymen, Foremen, and others. Instruction in Mechanical and Electrical Engineering, Technical Chemistry, Applied Art, Cabinet Making, Metal Plate Work, Plumbers' Work, Carpentry, Joinery, Bricklaying, &c. Fees from 7s. to 30s. for the Session, inclusive of Laboratories and Workshops.

The NEW SESSION COMMENCES OCTOBER 4th, 1883.

For Programme of Instruction apply at the College, Tabernacle-row, E.C.; or at the Offices of the Institute, Gresham College, E.C.

CITY and GUILDS of LONDON INSTITUTE.

TECHNOLOGICAL EXAMINATIONS.—The NEXT EXAMINATION will be held on MAY 28th, 1884. Teachers desiring to form classes should apply at once to the Director, at the Office of the Institute, Gresham College, London, E.C.

The Programme for 1883-4 is now ready.

PHILIP MAGNUS, Director and Secretary.

ELECTRICAL and MECHANICAL ENGINEERING.—A complete COURSE of INSTRUCTION in the above, extending over two or three years, will be given in the Workshops and Laboratories of UNIVERSITY COLLEGE, NOTTINGHAM, commencing in October next. The workshops will be furnished with all the ordinary machine tools, including a 10in. screw-cutting gap lathe, a 6ft. planing machine, cupola, brass furnace, &c. The machinery and dynamos will be driven by a 20 horse-power (nominal) Roby engine.

The school is under the supervision of Professor Garnett, assisted by Dr. John Ryan (both formerly Whitworth scholars), and others. It is affiliated to the City and Guilds of London Institute for the advancement of Technical Education.

The fees for students spending their whole time in the shops will be about £20 per annum.

For further particulars and for information respecting evening classes for artisans, apply to the SECRETARY, at the College.

September, 1883.

THE HAMMOND COMPANY ELECTRICAL ENGINEERING COLLEGE, 2, Red Lion-square, W.C.

Principal: HUGH ERAT HARRISON, B.Sc. (London).

Electrical Engineer: FREDERICK C. PHILLIPS.

A LIMITED NUMBER of STUDENTS will be ADMITTED for the NEW SESSION up to September 25th.

Applications should be made to the undersigned, at the offices of the Company, 110, Cannon-street, E.C., from whom full particulars may be obtained.

PHILIP A. LATHAM, M.A., Secretary.

A YOUNG MAN, well educated, who has studied the Theory of Electricity at one of the best schools, is desirous of OCCUPATION, being well up in Electric Lighting, Dynamos, Telephones, Testing, &c.

Address, R. N. S.,
2, Arkwright-road,
Hampstead, N.W.

WANTED, Situation as ELECTRICIAN or ELECTRICAL ENGINEER. Considerable experience in Erection and Management of Arc and Incandescent Light Insulations, &c. Address, 26, Penton-street, N

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NOTES.

King's College.—On October 5 Mr. Day will lecture here on "The Vagaries of a Molecule."

Magnetic Observations in Canada.—A magnetic survey of the north-west of Canada is to be made.

A Belgian Electric Society.—It is rumoured that a Society of Electricians for Belgium is talked of in that enterprising little country.

New Cable.—It is stated that the Swedish and Danish Governments have decided to lay a new cable between Helsingborg and Elseneur.

Electric Light for Contract Work.—The contractors for the new Blackfriars railway bridge are using the electric light to facilitate work at night.

Pneumatic Tubes in New York.—Following the example of our Post Office, the Western Union Telegraph Company are laying pneumatic tubes in New York, to facilitate the despatch of telegrams.

Wires Down in Ireland.—A hurricane broke over Ireland on Wednesday morning, doing a great amount of damage, and among other things, interrupting telegraphic communication all over the country.

Electric Light in Amsterdam.—The Amsterdam telegraph offices are lighted by five Siemens differential arc lamps, which replace 45 gas burners. The lamps are estimated to give about 36 carcels each.

Electric Light at Limerick.—Messrs. Shaw and Sons, of Limerick, who adopted the electric light last season, have been so pleased with the result that they are increasing their plant by 100 additional Swan lamps.

Cable Repaired.—Telegraphic communication with British Columbia and Vancouver's Island is restored. The communication with Brownsville (Texas) is still interrupted. The cable between Chorillas and Arica is also repaired.

Photographing Lightning.—According to a Vienna paper Robert Haensel succeeded in photographing a flash of lightning at Reichenburg, in Bohemia, during the summer. The point where the flash struck the earth was clearly shown.

Electric Light in Cork.—Messrs. O'Brien Brothers, of Cork, are lighting their new factory with 150 Swan lamps. The dynamos (Bürgin-Crompton) have been manufactured for Mr. Greenhill, of Belfast, and he has also supplied the fittings, &c.

West Coast of America Telegraph Company.—This company notify the restoration of communication "*viâ* Galveston," with Valparaiso, Iquique, Santiago de Chili, Buenos Ayres, and all stations in Peru, Chili, the Argentine Republic, and Uruguay.

Incandescent Lamp Carbons.—In the case of Weston *v.* Sawyer and Mann, which was recently heard in the United States Court, priority of invention for improvements in manufacturing carbons for incandescent lamps was awarded to the plaintiff.

Personal.—A Reuter's telegram states that Mr. W. E. Forster, Sir James Anderson, Mr. John Pender, M.P.; Capt. Shaw (Superintendent of the London Fire Brigade), and other gentlemen dined at the British Legation at Athens on Monday evening.

The Telephone in Scotland.—A telephone line has been erected between Coll and Brekach in Scotland, a distance of five miles or more. When tested the line is reported to have worked admirably. It has been erected by Mr. W. C. Muir, of 140, Douglas-street, Glasgow.

Electric Lamp Factory.—The Thomson-Houston Electric Company, of Boston, has just completed its new factory at Lynn, Mass. It is of brick, three storeys high, and has a floor area of 50,000 square feet. The company is turning out 100 arc lamps per week besides dynamos.

Central and South American Telegraph Company.—*The Times* Philadelphia correspondent, telegraphing on the 21st inst., says:—"The Central and South American Telegraph Company have finished their lines to Brazil, *viâ* Galveston, Texas. It was opened for business to-day."

Electric Lighting at Stockholm.—Some of the streets in Stockholm are now being lighted very successfully by means of twelve Pilsen lamps, fed from a Schuckert 12-light dynamo machine, driven by a 10 h.-p. nominal portable gas engine of Swedish make. The Press speaks very favourably of the Pilsen lights.

Cable Interrupted.—The Brazilian Submarine Telegraph Company notify the interruption of their St. Vincent-Pernambuco cable. As an alternative route has just been established, messages can now be sent direct to the Brazils and any part of South America, by any of the Atlantic companies' lines, *viâ* New York and Galveston.

Earthquakes.—It is reported that two strong shocks of earthquake were felt on Sunday last at Casamicciola. A house situated in the upper town was wrecked, and fell in ruins. No lives were lost. Several shocks of earthquake were also felt in Agram on Tuesday night and early on Wednesday morning. No damage is reported, however.

Gas Profits.—A gross profit has been made by the Gas Committee of the Manchester Corporation on the year's working of £99,489, and after paying interest on loans and the cost of lighting the streets of the city, the committee are able, by taking £12,000 from the reserve fund, to make a grant of £52,000 towards the cost of public improvements.

Perpetual Motion.—On Tuesday a foreigner, giving the name of Anthony Rivière, was charged at Brighton with being a lunatic at large. He was arrested at the post office, where he had written a number of telegrams to the Queen, the Prince and Princess of Wales, and others, stating that he had discovered perpetual motion. He was ordered to be sent to an asylum.

Electric Light at Belfast.—Messrs. Harland and Wolff, shipbuilders, of Belfast, have adopted the electric light on a large scale. They will shortly have in use 28 Crompton arc lights and upwards of 200 Swan lights. The work of installing these has been entrusted to Mr. J. H. Greenhill, of Belfast, who will also make the Bürgin dynamos required, he having a license to manufacture these machines in Ireland.

Copper Conductors.—We have received from Messrs. Walter T. Glover and Co., of Manchester, a revised copy of their table showing the relative dimensions, lengths, resistances, and weights of copper wire, to which we notice they have made one or two useful additions since its issue in June last. The weight and resistance per knot are now given, and some footnotes have been added, giving the value of the knot in yards and feet, &c.

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The Cost of Electric Lighting.—In Berlin the lighting of the arcade which extends from the Friedrichstrasse to the Unter den Linden promenade, by means of 10 Siemens arc lamps, has given the following results:—For 4½ hours the cost has been 5.48f. per hour, each lamp having a candle-power of 50 carcels. The cost of gas for the arcade amounts to 12,000 marks per annum; the electric light only costs 5,642 marks.—*La Lumière Electrique*.

Books Received.—"Die Anwendung der Elektricität für Militarische Zwecke," von Dr. F. Waechter; "Die Electrotechnik in der praktischen heilkunde," von Dr. R. Lewandowski; "Die verkehrs telegraphie der gegenwart, &c.," von J. Sack; "Die grundlehren der Elektricität," von W. Ph. Hanck; and "Die Elektricität," von Th. Schwartze, E. Japing, and A. Wilke. All of which are published by A. Hartleben, of Vienna, Pesth, and Leipzig.

Sunday Telegrams in Germany.—The Berlin correspondent of *The Times*, telegraphing on Sept. 24, says:—"An abridgment of office hours in the telegraph service on Sundays and church holidays has been decreed in so far as the requirements of the public and local circumstances will permit. On such days telegrams will be received only from 12 to 1 p.m. At places where there are several telegraph offices some of them may, if circumstances permit, be closed altogether on such days."

Tenders for Lighting Wanted.—The Padstow (Cornwall) Local Board require tenders for lighting the town with oil, gas, or electricity. Further particulars can be had of the clerk, Mr. William H. Pope.—The Taunton Town Council also invite tenders for lighting the public lamps in that town (350 in number) with coal gas, electricity, or other means, for three years. Further particulars can be had at the Municipal Offices, East-street, Taunton, and tenders are to be delivered by 1st October.

Telephony Extraordinary.—Canadian papers state that a certain Mr. Webster Gillett claims to have invented an instrument by means of which conversation can be carried on between points 2,600 miles apart. An experimental test of another system of telephony was to have been made between Montreal and Toronto, but the company's works in New York were burnt down just prior to the date fixed for the trials, and so they were postponed. Our readers can believe as much of this as they like.

Telegraphic Extension in Canada.—Telegraphic communication by the Canadian Pacific Railway service is now open from Port Arthur, on Lake Superior, to Calgary, at the foot of the Rocky Mountains, a distance of about 1,300 miles. The through telegraphic connection between this country and Kamloops, in British Columbia, will shortly be established by the erection of wires along the north shore of Lake Superior, and through British Columbia, in advance of the construction of the railway on these two sections.

The Electric Launch at Vienna.—On Tuesday last the electric launch belonging to the Electrical Power Storage Company conveyed a distinguished party on the longest trip yet made in such a vessel. The launch started from Vienna, and followed the course of the Danube to Pressburg, a distance of about 50 miles, accomplishing the journey in four hours, or about 12½ miles an hour with the stream. This launch is the joint production of the above company, Messrs. Siemens Bros. and Co., and Messrs. Yarrow and Co.

Electric Lighting for Ships.—The new ironclad "Italia," belonging to the Italian Navy, is to be fitted with five electric search lights of 1,600 carcels-power, and two of 200 carcel-power for boat use. A plant consisting of one Edison L dynamo and 150 A lamps is being installed on the U.S. steamer "Trenton," now at the Brooklyn naval yard. The Oregon Railway and Navigation Company's steamer "Alaskian" is also to be lighted by 300 B lamps. The current will be supplied by an L dynamo in this case also.

Protecting Oil Tanks from Lightning.—An American inventor, Mr. H. C. Thomas, of Rock View, N.Y., has patented the following method of protecting oil tanks from lightning. The roof is covered with an asbestos sheathing, which acts as an insulator. Over this is placed a sheet-iron covering, which forms the outer roof, so to speak. A series of conductors radiate from a pointed rod placed in the centre of the roof, and are led down to good earth. It is hoped by this means to diminish the risk of the tanks being fired by lightning.

Quick Work.—On the 17th inst. the Pilsen Company were requested to light up the western and foreign wing of the Fisheries Exhibition, and on the evening of Wednesday, the 19th inst., fourteen Pilsen arc lamps, of 200 c.-p., were running successfully, 14 other lamps of the same kind being added on the 20th inst. Considering that this installation involved the running of nearly a mile of leads, besides the fixing of dynamo machines and other apparatus, the Pilsen-Joel Company are to be congratulated upon the ability and promptitude displayed by their staff.

Electric Lighting Regulations in Austria.—The Committee of the Electric Exhibition, taking advantage of the presence of many of the most prominent electricians at the present time in Vienna (says the Vienna correspondent of the *Standard*), has instituted a commission to draw up regulations to be imposed on electric companies as the condition of granting them concessions, on the model of those already existing in England. The result of the labours of this commission will be laid before an international committee, in which the Austrian Government will be represented.

University College, London.—The Department of Applied Science and Technology in this college opens on the 2nd October, at the same time as the rest of the college. The instruction in this department includes (1) lectures on different branches of civil and mechanical engineering and surveying and levelling; drawing and practical experimental work in the engineering laboratory; (2) lectures and practical laboratory work in electricity and allied branches of physics; (3) lectures in architecture and architectural construction; and (4) lectures and practical laboratory work in different branches of chemical technology, including brewing, heating and lighting, metallurgy, chemistry of the alkali trade, and agricultural chemistry. Besides these technical and professional lectures the Faculty of Science provides very complete courses of lectures in mathematics, physics, chemistry, and geology, the sciences upon which the professional knowledge must be based.

Edison Fire Alarms in Hotels.—An ingenious device has been arranged in connection with the circuits of the Edison Central Station in Santiago, Chili. There are four hotels in the district lighted, and in each of them is being introduced a series of fire alarms. In addition to the lamp or lamps used to light the bed rooms, another lamp has been placed near the ceiling of each room, so as to be out of reach of the occupant, while other lamps are arranged in the halls and at the exits. Electric bells are also placed in the halls. The whole of these lamps and bells are embraced in one circuit which terminates in a switch placed in a recess in the

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wall in some conspicuous place. This recess is covered by a pane of glass to protect the switch from careless or malicious use. In case of a fire breaking out in the hotel this pane of glass is to be broken and the switch closed, thereby lighting all the lamps and ringing the bells. By this device, therefore, the guest is not only apprised of the danger, but is provided with sufficient light by which to escape. The cost of installation is small and the working expenses trifling, while the arrangement is simple and not likely to get out of order.

Post Office Telegraphs.—The report of the Civil Service Commissioners for last year has just been issued. It is astonishing how long it takes to issue some of these reports; so long, indeed, in some cases, that all interest in the subject matter has completely died away. In the present report we are told that "an increase of nearly 3,000 cases under the Order in Council of June 4, 1870, is owing, in part, to a considerable development of the system of open competition as applied to the appointments of female clerk and female telegraph learner in the Post Office, but it is mainly due to a general increase in the average ratio of competitors to vacancies, which, in 1881, was 6·5 to 1, and in 1882 was 10 to 1." Further on the report says:—"The results of the first open competitions for the situation of female clerk and that of female telegraph learner, which took place in the autumn of 1881, were given in detail in the report for that year. In 1882 similar competitions were held, two for each class of appointments. At the two competitions for female clerkships 366 candidates were examined for 116 appointments. At the other two competitions 1,385 women were examined, of whom 70 were admitted to the telegraph school."

The Rysselberghe System.—In May, of this year, a regular telephonic service, on the system invented by M. van Rysselberghe, of the Brussels Observatory, was commenced between the House of Parliament at Brussels and the printing office of *La Flandre Libérale*, at Ghent, on one of the ordinary telegraph wires. The telegraph wire is incessantly at work conveying telegraphic messages, and simultaneously it conveys, by means of the telephone system, the reports of the parliamentary debates, dictated in the Chamber at Brussels and heard in the printing office at Ghent. The *Daily Exchange* reports from the Bourse, including hundreds of quotations in figures, are also, we are informed, transmitted correctly, by word of mouth, over this telegraphic wire. In August of this year, the Minister of Public Works in Belgium established, at the expense of his Government, an experimental service between Brussels and Antwerp, the results of which were, we believe, considered very successful. The system is also about to be introduced into Holland, a contract having been entered into by the Government with the proprietor of the patents for a definitive installation upon the telegraph wires between Amsterdam and Haarlem. This service is expected to be in action about the 15th October, when the public will have an opportunity of practically testing the system.

Making Carbons.—Messrs. John Robertson and Co., of Brooklyn, New York, have constructed a hydraulic press for making electric light carbons. It consists of a main cylinder, copper lined, with a double-acting water ram. This ram is kept in line by a heavy gland, which in turn is guided by heavy brace rods that hold the water and carbon cylinders together. Around the carbon cylinder there is a steam jacket for the purpose of heating the mixture to the proper temperature before it is pressed. When this point is reached the tension is applied, and the carbons are forced through a die at the end of the cylinder. The fit of the ram is so close that it is necessary to force it back as well as forward, and this is accomplished by applying a reversed pressure, which greatly accelerates the work. The material used for making the carbons is (says the *American Machinist*) the purest carbonaceous substance that can be found, and the finest coke or the lining of gas retorts is generally selected. These materials are ground to an impalpable powder, and mixed with an adhesive substance before being put in the cylinder. After coming through the dies the carbons are dried in an oven, then roasted in a crucible. When they emerge from this hot ordeal they are intensely hard and compact, the fracture resembling steel, and they ring like a metallic rod. Dies for this press are made to produce carbons varying from $\frac{1}{8}$ of an inch to $\frac{1}{2}$in diameter.

The New Patent Bill.—The *Scientific American* makes the following comments on the new Patent Bill which was passed at the end of the last Parliamentary Session. Our contemporary thinks that "the new act will give a great impetus to the taking out of patents in Great Britain, for it may be fairly calculated that a proportion of the patents taken out in the United States and in other countries will also be secured in England. It is not proposed, under the new law, to follow the system of examination as in the United States and Germany, but to adhere to the practice hitherto prevailing in England; that is to say, to issue the patent to the applicant without examination, at his own risk. It is, nevertheless, proposed to create a body of examiners whose principal duties will be to see that the invention described and claimed in the final specification is the same as that described in the provisional, and that the scope of the patent is strictly limited to a single invention. This is an excellent provision, and ought to be adopted in our law. Our present system of official examination is, practically, a hindrance and an annoyance to the inventor, not a benefit. It delays the issue of his patent, and in many cases involves him in expensive and harassing interference contests, which after all decide nothing, as the Courts are obliged to review the Patent Office work and determine the validity of the patent. The United States, Canada, and Germany are now almost the only countries that pretend officially to examine. In other countries the patent is always granted, and the inventor examines for himself. If he chooses to pay the fees he may take out a patent, but if it should afterwards appear that the invention was lacking in novelty or utility, then the patent is worthless. This is a straightforward system, and works well in all countries where it is in vogue; its adoption here would be a decided improvement in favour of inventors, it would lighten the duties of our Patent Office examiners, and enable them to do better work in respect to those necessary features of examination which the new English law contemplates."

Accidents from Lightning.—M. Colladon, of Geneva, who has given considerable attention to the phenomena of thunderstorms, states in a recent note to the Paris Academy of Sciences that the present year has been exceptionally prolific in thunderstorms. He calls attention to the fact that in 1868 there were also an unusual number of thunderstorms. In the present year he says that the number of lightning strokes, if we may so call them, which occasioned deaths and fires far exceeded the average of the last twelve years in a portion of Europe, and Switzerland in particular. He thinks that physicists and meteorologists ought in the cause of humanity to make it a duty to point out, whenever possible, the local causes which appear to them to have been the occasion of a fire caused by a lightning stroke, and to insist on such elementary precautions as might have prevented such a

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disaster. He then cites one or two remarkable instances of fires caused by lightning, and the probable reasons why the building was struck. In one case, on the 15th August last, at 1 a.m., a farm building was struck at Bourdigny in the Canton of Geneva, and entirely destroyed; a second flash struck a poplar about eighty metres distant, while a third struck a vine a little further off. Only a short interval separated these flashes. He gives a drawing of the farm building in section. From this it appears that the lightning must have struck the iron roof, run down an iron stay rod inside the building, and then, finding no other conductor handy, jumped across to a large cistern of water, which was in connection with the earth by its supply pipes. In jumping across this distance the lightning fired the building. A portion of the flash, however, appears to have entered an iron wire stretching from this building to another, and to have killed a watch dog who was attached to this horizontal wire by a vertical wire and pulley, allowing him to run backwards and forwards across the yard. M. Colladon points out that had there been a continuous conductor from roof to earth this building would have been saved. He remarks that metal is much in vogue now for building purposes, and that many houses and farm buildings are provided with cisterns of water, and are in much the same case as the building destroyed at Bourdigny. He recommends the erection of a continuous conductor, in order that lightning may go to earth instead of burning our houses about our ears. This advice has been given many times before, but how little it has been heeded is shown by our daily press every succeeding summer.

Measuring Telephonic Sounds.—In the *Annalen der Physik und Chemie*, Vol. XIX., Heft 1, No. 5, Herr K. Vierordt gives an interesting account of his experiments on the measurement of the decrease of sound in the telephone, of which the following abstract appeared in the *Journal of the Society of Telegraph Engineers* for September:—"Two of Siemens and Halske's telephones, of the latest pattern, were placed in two rooms so far apart that no direct sound was transmitted, and were connected up in simple circuit. The first telephone was placed 3cm. above a tin plate 222mm. by 172mm. and 8·2mm. thick, lying on a table. The second telephone was fixed in a stand. While the experimenter listened at the second telephone, taking care that his ear did not touch it, an assistant let fall lead bullets from varying heights on to the tin plate below the first telephone. The source of sound was thus the shock of the bullet on the tin plate. Starting with a heavy bullet and a considerable fall, the assistant gradually decreased both, as directed through the telephones by the experimenter at the other end, until a sound was produced under the first telephone which was only just audible in the second. The experimenter now placed his ear at the same distance, 3cm. above the tin plate, as was before occupied by the first telephone, and the assistant again let fall bullets from various heights until a point was reached at which the sound, heard thus directly, was only just audible. If we call the former sound S^1, and the second S, the loss of sound by transmission will be $S^1 - S$. In an experiment tried at night, when all was quite still, a sound was just heard in the second telephone, when a bullet weighing 1,542mg. was let fall from a height of 7mm. on to the tin plate. The strength of the sound was then calculated to be $S_1 = 1549 \times 7^{0 \cdot 62} = 5176$mg. mm. When listening directly, a sound was just heard when a bullet weighing 2·4mg. was let fall from a height of 12mm. Hence $S = 2 \cdot 4 \times 12^{0 \cdot 53} = 8 \cdot 95$. Hence, when expressed in units of sound of the tin plate, which weighed 2,406g., the loss of sound was $5{,}176 - 8 \cdot 95 = 5{,}167 \cdot 1$. It should be added that the exponent of the height of the fall was found by Oberbeck's method. Two lead bullets respectively 2,073mg. and 888mg., hence $\frac{P}{p} = 2 \cdot 334$, gave the co-efficient 0·6196, or in round numbers 0·62 in the one case; and two other bullets respectively 17·5mg. and 8·75mg., $\frac{P}{p} = 2$, gave 0·529, or nearly 0·53."

On Hall's Phenomena.—At the last meeting of the Paris Academy of Sciences a note on this subject by M. Aug. Righi was read, of which the following is the pith:—The author states that his researches on this important phenomena have produced two results. The first relates to the form of plate to be used. Instead of being in the form of a cross with four electrodes, it has some absolute form and carries three electrodes. The current enters or leaves by one of these, and leaves or enters by the other two. The two partial currents circulate in an opposite direction in the two circuits of each of the coils of a Wiedemann galvanometer. The introduction of a known resistance, or the traversing of two other coils by the total current, enables the needle to be kept at zero, or nearly so. The instrument receives variations in the intensity of the two partial currents of an opposite nature, when the circuit of the electro-magnet—between the poles of which the plate is placed—is closed. The direction of the deflection shows that the equipotential lines are deflected in a contrary direction to the magnetising current, for gold and other metals in which the Hall phenomenon is of the same character, and in the same direction as the magnetising current for iron. By changing the direction of the current which traverses the plate, deflections of the galvanometer are obtained which show that the effect is not to be explained by a direct action of magnetism on the current. This mode of operating permits the use of plates of very small and altogether irregular dimensions, provided they are sufficiently thin. The second result relates to the Hall phenomenon in bismuth, a metal for which it has not yet been studied, perhaps owing to the difficulty of obtaining it in sufficiently thin or wide plates. By the foregoing method, the author has ascertained that the Hall effect with bismuth is of the same character as with gold, but of extraordinary intensity, about 5,000 times that of gold. Further, with the same current and similar dimensions, a plate of bismuth ·079 mm. thick has given deflections five or six times greater than a goldleaf of ·000087 mm. thick. The Hall effect is also obtained in bismuth with a simple magnetised steel bar, in place of the electro-magnet. Latterly, the author has managed to make very thin plates of bismuth, sufficiently regular to enable the ordinary cruciform shape to be given to them. With a small magnetised bar, the poles of which were caused to approach the plate alternately in succession, he obtained the Hall effect sufficiently to cause galvanometer deflections (permanent, if the magnet is kept in place) of half a meter of the scale. He is now working to perfect the construction of very thin bismuth plates, and is convinced that he will obtain the Hall effect by means of the influence of terrestial magnetism alone.

Electric Lighting for the City.—At the meeting of the City Commissioners of Sewers on Tuesday last, Mr. George Shaw presiding, a report was brought up from the Electric Lighting Committee by Mr. E. J. Stoneham on the reference empowering them to prepare a draft license, framed on the principle of the commissioners undertaking the supply of electricity in the City, and to contract with reliable companies for that supply. They advertised, inviting proposals for areas not exceeding in each one-eighth of the entire

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district, and they received replies from the Gülcher, Hammond, Jablochkoff, Maxim-Weston, Metropolitan Brush, and Pilsen-Joel Companies. The nature of those replies made it evident that both in negotiating a contract with the companies to be embodied in a license, and in opposing the applications for a provisional order before the Board of Trade, it would be necessary to obtain the advice and assistance of skilled electricians, and they had therefore retained the services of Mr. W. H. Preece, F.R S., of the General Post Office, and Mr. Heaphy, of the Phœnix Fire Office. The proposals of the companies being considered vague and unsatisfactory, the committee requested Mr. Preece to prepare a specification for lighting an area of the City by electricity, in accordance with the provisions of the Electric Lighting Act and the regulations of the Board of Trade. In the meantime certain of the companies modified their proposals, and it was decided that the Maxim-Weston, Gülcher, Pilsen-Joel, Metropolitan Brush, and the Telegraph Construction and Maintenance Companies should have an opportunity of tendering in accordance with the specification. The committee now requested authority to make certain experiments, at a cost of £200, with a view to determine the best distribution of incandescent lamps of the proper intensity of light, so that the companies tendering might have before them definite figures to guide them in fixing their prices.—Mr. Stoneham moved the adoption of the report.—Mr. Innes, in adversely criticising the action of the committee, thought it would be impossible for electric lighting companies to light the streets at a profit unless they made a charge which the ratepayers would not be inclined to bear. The sum paid to the gas companies for street lighting was exceedingly small, but the companies made their profits by supplying private houses and warehouses along the route. If any arrangement were made with the electric lighting companies they should be allowed to make their own bargains with private owners, and if that were done the streets would soon be lighted by electricity. He doubted the wisdom of the proposed experiment.—After some further discussion the report was adopted, and Mr. Innes gave notice that it was inexpedient to continue the Electric Lighting Committee, and that the reference be transferred to the Streets Committee.

The Properties of Hydrogenised Platinum.—The *Ann. Phys. Chem.*, Vol. 19, pp. 300-319, contains a paper by C. Fromme on this subject, of which the following abstract appears in the *Journal* of the Chemical Society for September:—The author was led to suspect that the peculiar phenomena observed when platinum is the positive pole in a chromic or nitric acid battery were possibly due to the property of this metal of absorbing and of condensing hydrogen. He has accordingly examined the electric properties of platinum and palladium when containing hydrogen. Before the experiment, the palladium was freed from traces of oxide and of hydrogen; the measurements of E.M.F. were made with open circuit. The ratio of the E.M.F. of the Zn—Pt to the Zn—Pd element was found to be 1 : ·934. The first form of the experiment adopted to determine the electric properties of hydrogenised platinum and palladium consisted in introducing the metals into sulphuric acid saturated with hydrogen. Under these conditions the E.M.F. of the Pt | H_2SO_4 element had a constant value of ·71 Daniell, while that of the Pd | H_2SO_4 element was at first ·92 Daniell, and then it slowly decreased. The difference in behaviour the author explains by the readiness with which platinum condenses hydrogen on its exterior surface, while palladium absorbs the hydrogen into its interior. In other experiments the metals saturated with hydrogen were introduced into sulphuric acid free from gas; the E.M.F. of the combination Zn | H_2SO_4 | Pt was about 18 per cent. less than the same combination with the pure metal. After eight minutes the difference was only 8 per cent. In the case of palladium the E.M.F., after a polarisation of short duration, reaches a minimum value of ·75 Daniell. The author further examined with a rheostat the E.M.F. of the combinations Zn | H_2SO_4 | Pt and Zn | H_2SO_4 | Pd (the acid and the metals being free from hydrogen), and established that the relation of the E.M.F. of Pt and Pd decreased from 1·07, and then increased to 1·14, when the resistance decreased from ∞ to 0; if the resistance of the rheostat be ∞, then with greater resistance in the circuit the E.M.F. of the Pd element is the greater, but with less resistance the E.M.F. of the Pt element is the greater. The author then proceeds to offer an explanation of the phenomena of the variation of the E.M.F. in the chromic and nitric acid batteries. The well-known property of palladium of absorbing hydrogen is sufficient to account for these variations, but in the case of platinum the evidence is not so clear. When a Grove element is first closed, a layer of hydrogen gas appears at the surface of the metal, but it subsequently disappears. This hydrogen is subject to two opposing forces, the one from the nitric acid tending to oxidise the hydrogen, the other from the platinum tending to condense the gas upon the surface of the metal, and of absorbing it into its interior. If at the outset the platinum contains no hydrogen, then the latter force preponderates, and to a greater extent the more dilute the acid, and the greater the intensity. With a greater concentration of acid, or with less intensity of current, these conditions are reversed. Sometimes the platinum condenses a portion of the hydrogen, while another portion is oxidised by the acid, and as a necessary consequence the E.M.F. falls; when it reaches a minimum, then the thickness of the hydrogen layer no longer increases, and all the gas is oxidised by the acid. As soon as the hydrogen condensed on the surface begins to combine with the platinum molecules on the surface of the metal, then the E.M.F. increases in proportion as the attraction of the hydrogen for the platinum decreases, while that of the hydrogen for the oxygen increases. The E.M.F. never attains its former value, on account of the hydrogen absorbed by and combined with the platinum. During the opening of the circuit the E.M.F. suddenly rises until it reaches a maximum, while the hydrogen on the surface of the metal is oxidised, and the combined hydrogen is separated off. Shaking the platinum causes the hydrogen to be given off from its surface, while a rise of temperature of the acid diminishes the evolution of the oxygen. The effects produced by these changes in the conditions will act in an opposite direction. The similar phenomena observed in the chromic acid battery cannot be attributed entirely to the absorptive power of platinum for hydrogen. The author supposes that the chromium sesquioxide, the product of the oxidation of the hydrogen by the chromic acid, forms a compound with the platinum. This supposition is not based on any facts, but it appears to the author that no other explanation is sufficient. When the combination Zn | H_2SO_4 | H_2CrO_4 | Pt is closed a portion of hydrogen is oxidised, while another portion, the quantity of which is dependent on the intensity of the current, is taken up by the platinum, as no hydrogen is evolved in the free state. The chromium sesquioxide partly combines with the sulphuric acid, and partly forms a combination with the platinum, and this latter causes the decrease of the E.M.F., which again increases when the evolved hydrogen turns out the chromium sesquioxide, and in its turn combines with the platinum.

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THEORY OF MAGNETO AND DYNAMO MACHINES.

XXV.

So far we have considered a revolving closed circuit traversed by alternating currents at every semi-revolution, and we have thus done something more general than would at first sight appear, for the revolving part need not necessarily form the whole circuit. There may be an external or stationary portion, and this may be traversed by continuous or by alternating currents, according as the ring is or is not supplied with a reversing commutator. A "Delezenne circle," or earth inductor, is, or should be, supplied with both kinds of commutator, one at each end of its axis; a tube split across the axis with a pair of springs resting each on its own half for alternating, and a tube split along the axis with springs touching alternate halves for unidirectional currents.

Theory of Alternate Current Machines.

Now, the first case is the simplest kind of alternating machine, and its complete theory is given in the last article without any difficulty whatever. Only remember that R and L are the resistances and self induction of the *entire* circuit—external as well as internal. If coils or magnets are included in the external circuit so as to make L large, the current is by them everywhere weakened, and the lag is increased. But then in alternating machines nobody need trouble about the lag; there are no brushes to set at particular places, there is no tendency to spark; everything goes on all right, and lag may be left to take care of itself. At the same time you will not get much power out of your machine if you let L be very large, as is obvious by looking at the equations of the last article, repeated below. So the introduction of coils containing iron into the circuit will greatly weaken the current, and even the introduction of an iron core into a coil already included in the circuit will weaken the current just as if so much resistance had been added; and this is a convenient and an economical mode of regulation which has been patented by Dr. Hopkinson. Pretty well the whole theory of alternate current machines is contained in the simple equation for the strength of current deduced last time, and which we here repeat, viz.,

$$\gamma = \gamma_0 \cos\phi \sin(\omega t - \phi),$$

or more explicitly

$$\gamma = \frac{H A \omega}{\sqrt{(R^2 + L^2\omega^2)}} \sin(\omega t - \phi),$$

where

$$\tan\phi = \frac{L\omega}{R},$$

and

$$\omega = \frac{2\pi}{T},$$

T being the periodic time of the machine, as has been pointed out by M. Joubert and Dr. Hopkinson. For instance, we see this at once, viz., that as the speed increases, the current does not increase indefinitely, but tends to a maximum value,

$$\frac{H A}{L} = \gamma_\infty.$$

At high speeds, therefore, the amount of self induction is a far more important consideration than the simple resistance; whereas at low speeds it is the resistance on which the strength of the current mainly depends.

The total or actual E.M.F. is simply $R\gamma$, provided the circuit contains no condenser or polarisation plates or any back-E.M.F.-producing machines; hence the E.M.F. obeys the same kind of laws as the current.

The impressed or applied E.M.F. is not this, however, but is $H A \omega \sin \omega t$; the resultant E.M.F. contains another term, $L\frac{d\gamma}{dt}$, and it is the effect of this that makes the resultant

$$e = H A \omega \cos\phi \sin(\omega t - \phi).$$

The power developed electrically and spent in producing heat is

$$\frac{2}{T}\int_0^{\frac{1}{2}T} e\gamma\, dt, \quad \text{or} \quad \frac{2}{T}\int_0^{\frac{1}{2}T} R\gamma^2\, dt,$$

which is

$$P = \tfrac{1}{2} e_0 \gamma_0 \cos^2\phi$$

$$= \tfrac{1}{2} H^2 A^2 \omega^2 . \frac{R}{R^2 + L^2\omega^2} \text{ watts.}$$

Now, this equation shows that though the current may be weakened by increasing R just as well as by increasing L, yet the latter process is the more economical, in that it consumes less power—wasting, in fact, none. It further shows that there is a best value of the resistance of the circuit at which the power developed at any given speed will be a maximum, viz., when

$$R = L\omega.$$

This maximum power for the given speed being

$$P_m = \frac{H^2 A^2 \omega}{4 L} = \frac{(H A \omega)^2}{4 R} = \left(\frac{H A}{L}\right)^2 \frac{R}{4},$$

but in no way is it possible to overstep the upper limit of power, attainable only at an infinite speed,

$$P_\infty = \left(\frac{H A}{L}\right)^2 \frac{R}{2} = 2 P_m.$$

The *efficiency* of the machine, or the proportion between the power expended in the useful portion of the circuit to the total power, is simply the ratio of the resistance of this useful portion of the circuit (*e.g.*, incandescent lamps) to the total resistance; and it is independent of the value of L, the self induction, and of its location. Introducing coils or iron cores into any part of the circuit, therefore, diminishes the total power without affecting the efficiency; *i.e.* it diminishes the power equally in every part of the circuit.

A good deal more might be said about alternate current machines. For instance, the question might be discussed whether many machines can be used on a single circuit, instead of one large one. Also the question whether it is possible or not to use them as motors.

These questions have been discussed by Dr. Hopkinson in a lecture on Electric Lighting to the Institution of Civil Engineers, April 5, 1883, and answered in the affirmative; but the machines must be coupled in parallel circuit, not in series.

Again, it would be interesting to know what will happen in case the circuit of an alternating current includes condensers, or a series of voltameters, or thermopiles, or other polarisable surfaces in which an alternating E.M.F. is developed as the current fluctuates proportional always to the quantity of electricity which has passed. The complete answer to this is contained in the equation to the E.M.F. at any instant (S being the capacity of the condenser forming part of the circuit),

$$e = R\gamma = H A \omega \sin \omega t - L\frac{d\gamma}{dt} - \frac{1}{S}\int \gamma\, dt,$$

and it only wants digging out. It will be found that it is possible to make the condenser exactly neutralise the effect of self induction; viz., by making $\frac{1}{S}$ equal to $L\omega^2$.

Or, again, we might discuss the case where a constant battery E.M.F. is included in the circuit, which is simple enough, for it only superposes its own current on that of the machine, giving as the result,

$$\gamma = \frac{E}{R} + \gamma_0 \cos\phi \sin(\theta - \phi).$$

But as the discussion of alternating machines has slipped in here somewhat incidentally, and as leading up to direct current machines, we will not pursue the subject further at present. Reference may be made, however, to M. Joubert's recent paper, reprinted in *The Electrician* of August 25.

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Earth Inductor, with Reversing Commutator.

The earth inductor, arranged as it usually is for direct currents, is here merely taken as a simple type of direct current machine, and one to which exact calculation can be applied; but it must not be supposed that the investigation is to end with such a practically insignificant current generator as this. Its simplicity is due to the fact that it is a simple coil, without iron, rotating in a uniform field, and with the simplest form of commutator.

In one respect, however, it is rather less simple than a real Gramme or Siemens machine, viz., that the currents it produces, though all of one direction, yet fluctuate greatly—in fact, they vary between zero and a maximum—whereas currents generated by real machines are fairly, though of course by no means absolutely, constant. This distinction is of no moment so long as the outer portion of the circuit contain no induction coils, and we will therefore now suppose that the external circuit of the earth inductor is made up of simple resistance coiled back upon itself in the usual way to avoid all self induction.

Now, the first thing to notice about a commutator is that for economy the brushes should rest on the gaps at an instant when there is no E.M.F. in the coils; that is to say: for slow rotations when the plane of the coil is normal to the lines of force; but for quick rotations, when induction prolongs the action, at a time later than this corresponding to the angle ϕ, viz., $\frac{\phi}{\omega}$ths of a second after the plane of the coil was normal to the lines of force.

And this is true whatever the width of the gaps; for if the gaps are wide the right position of the brushes will give us most effect from the coil, while if the gaps are so narrow as to cause short circuiting, the necessity is still more urgent.

There are two important cases depending on the width of gap; first, when the insulating gap is wider than the brush contact, so that the same brush never rests on both halves of the commutator; and, secondly, when the insulating gap is narrower than the brush contact, so that the coil is short-circuited for an instant every half revolution. If there be any E.M.F. in the coil, whether "impressed" or self-developed, at the instant when the short circuiting takes place, there will obviously be power wasted in developing a strong current, which is of no use, and which may do damage by burning the contacts. Hence the necessity in this case for a careful adjustment of the lead of the brushes.

To avoid sparking it is also easy to see that the insulating gap must be narrow, for if it be wide it will evidently be impossible to set the brushes so that they both break contact with one brass piece and make contact with the other in a position when there is no E.M.F. in the coil; and if there be an E.M.F. in the coil the make or the break will be attended with extra current effects. It may be noticed, however, that the break only is accompanied by actual sparking; and, consequently, unless the gap is so narrow that the make and break are simultaneous, the best plan is to set the line of *break* in the true position for lead, viz., an angle ϕ in advance of the position in which the coil offers its greatest area to the field of force, ϕ being an angle whose tangent is $L\omega/R$. The effect of a wide gap will then only be loss of useful effect.

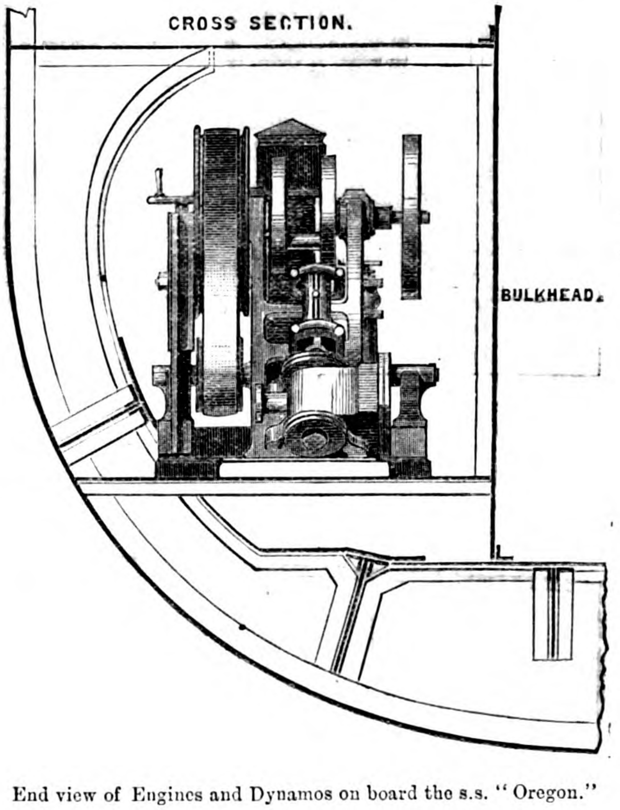
Overhead Wires in America.—An American contemporary states that the District of Columbia Commissioners have refused the applications of the Western Union and the Baltimore and Ohio companies to replace their old telegraph poles with new ones. They take the ground that the old poles will serve until the wires can be put underground.

Cottages Fired by Lightning.—During a thunderstorm which visited Worcester and its environs on the night of Thursday, Sept. 20, two cottages near Norton Barracks, about one mile from Worcester, were struck by lightning. One which was unoccupied was first ignited, and both were quickly in flames. No one appears to have been hurt, however.

INSTALLATION OF THE EDISON SYSTEM ON BOARD THE SS. "OREGON."

We this week illustrate the dynamo room of the latest addition to the Guion line of steamers. The installation is the most complete of any yet arranged on board ship, and consists of two 500-light Edison-Hopkinson dynamos, driven by two compound diagonal engines, designed and made by Messrs. Mather and Platt, of Manchester, who are also the makers of the Edison-Hopkinson dynamos for the Edison Company.

The space available for the electrical machinery being very limited, the design had to be made as compact as possible, and with this object the engines and dynamos were kept close together, and mounted on a large cast-iron bed plate made in halves and secured together, the whole being bolted to the ship's girders, as shown in our engravings.



End view of Engines and Dynamos on board the s.s. "Oregon."

The 500-light Edison-Hopkinson dynamos are of the marine pattern adopted by the Edison Company for use on board ship, running at 600 revolutions per minute, and driven by patent endless link belts. These belts having to be extremely short, an adjustable tightening pulley is added, so that more grip can be put on the pulleys by the belt, which can also be easily slacked off and changed if required by running the tightening pulley back, or, on the other hand, tightened up when necessary.

The engines each consist of a strong cast-iron A stand frame cast in one piece, having the bottom planed to fit on bed plate, and the faces for the cylinder feet and slides for crosshead accurately shaped and adjusted. The crank shaft pedestals are cast on the framing, and bored to receive the steps, which are turned to suit. The cylinders are fitted with Mather and Platt's patent piston with steel piston rod. The high pressure cylinder is placed on the right hand side, and is $8\frac{1}{2}$in. diameter. The low pressure cylinder is 14in. diameter by 12in. stroke, and has an ordinary slide valve worked by an excentric. The high pressure cylinder has the arrangement of valve gear and governors invented and patented by Mr. Pardon Armington, of Massachussets, U.S.A. By this means steam is supplied automatically in such quantities as will develop a uniform speed under all variations of load within the power of the engine. Owing to the peculiar and

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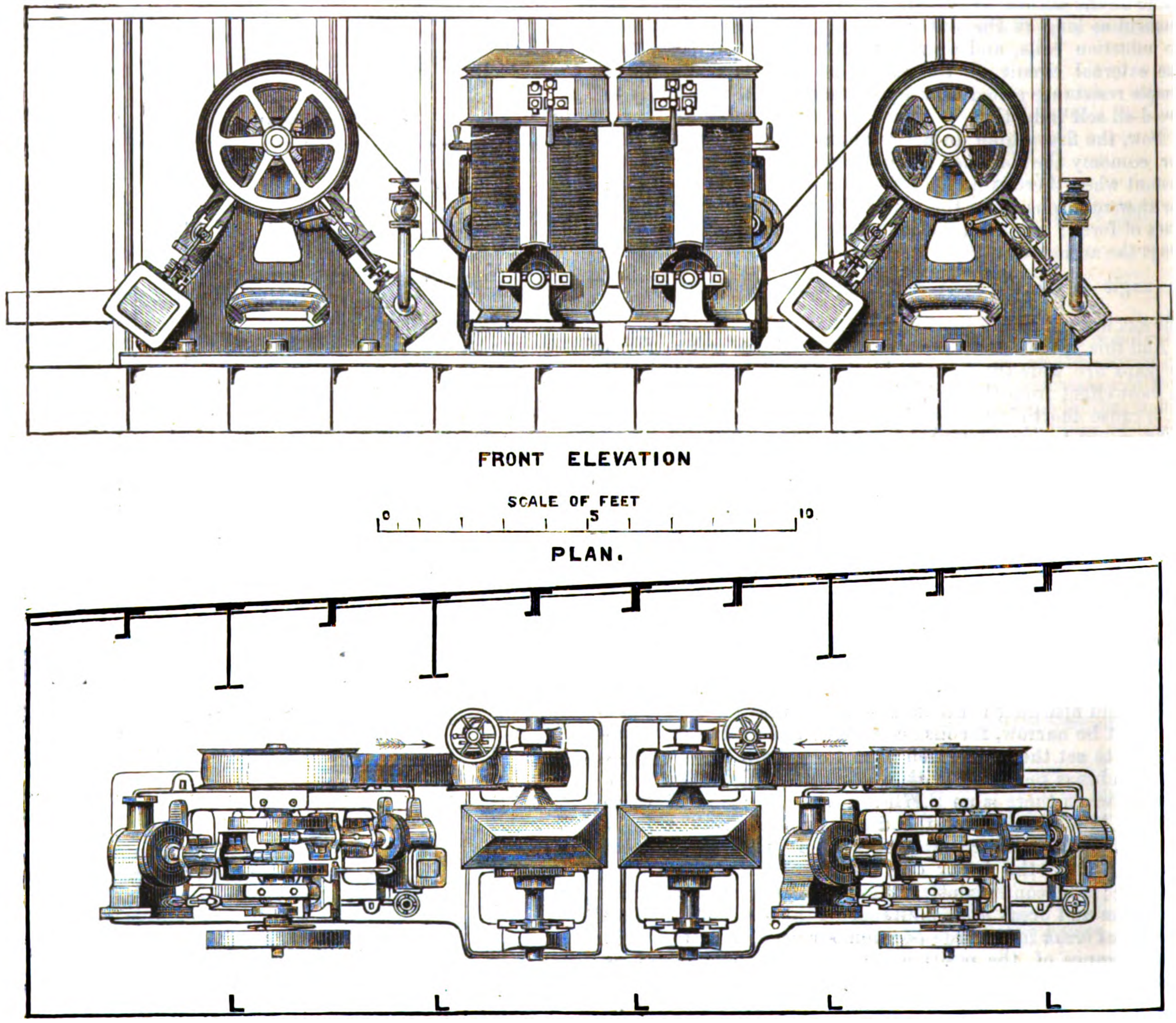
novel construction of the valve regulating the supply of steam to the cylinder, a larger quantity of steam is supplied to the piston at the end of each stroke in less time than is possible by any other arrangement. The construction of the governor allows the valve-operating excentrics to be worked directly by weights and springs operated by the centrifugal force generated by the speed of the revolving crank shaft, thereby forming a very sensitive governor, well adapted for marine work, there being no governor balls, &c., to be affected by the ship's motion. The normal speed of the engine is 300 revolutions per minute. The crosshead and pin moves in a circular slide, which can be taken up as required. The crank shaft is of steel, and has two cast-iron discs shrunk on the webs, which perfectly balance the engine. The bearings are special gun metal, and the proportions of the necks fully kept up, that on the driving side being 5in. diameter by $12\frac{1}{2}$in. long. The driving pulley is 3ft. 6in. diameter by 11in. broad, and is flanged on each side, as also is the tightening pulley, that the belt may not be affected by the ship's rolling. The wearing parts of these engines and dynamos are made of such proportions that all steps, caps, and slides are screwed home to prevent any possibility of their working loose. The oiling arrangement consists of a tank placed above engines, from which copper pipes conduct oil to all working parts, the quantity being regulated by small taps to each bearing to insure continuous running. All the bearings are supplied with water pipe and tap in case of dirt or dust getting into them, and to prevent heating.

The arrangements of the circuits are those usually adopted by the Edison Company, and of the kind found to answer so well in previous installations of this kind. The brackets and fittings, which are electro-plate, are very handsome, and have been supplied by Elkington. The total number of lamps employed on board is 460, all of 16 candle-power. With the exception of a few portable oil lamps, no other artificial light will be used but the Edison incandescent lamps.



Front elevation and plan of Engines and Dynamos on board the s.s. "Oregon."

The "Oregon" has been built for the owners of the Guion line of steamships by Messrs. John Elder and Co., of Fairfield, Govan. She is 520ft. long, 54ft. broad, and 40ft. 9in. deep. Her gross tonnage is about 7,500. She went for her trial trips last week, and is stated to have shown a speed of over 20 knots per hour, while her engines indicated over 1,200 horse-power. The boilers have been supplied by Mr. Samson Fox, of Leeds, and are on his patent corrugated principle. Taken altogether the "Oregon" represents the very highest developments in engineering and electrical science as applied to shipbuilding, and will be a great addition to the already numerous Atlantic liners.

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REPORT OF THE COMMITTEE ON ELECTRICAL STANDARDS.*

The committee report that, in accordance with suggestions made at the last meeting of the British Association, arrangements have now been completed for testing resistance coils at the Cavendish Laboratory, and issuing certificates of their value. The arrangements have been made by Lord Rayleigh and Mr. Glazebrook, and the report contains an account by Mr. Salter of the methods employed, and the conditions under which the testing is undertaken, in order that those who use these coils may have a more exact estimate of the value of the test.

The standards at the laboratory belonging to the association, the values of which have been recently tested, are all single units. The best of these were all compared among themselves originally by Hockin (B. A. report 1867), and again by Chrystal and Saunders (report 1876), and more recently at various temperatures between a limit of 0° C. and 25° C. by Mr. Fleming in 1879-81, and a chart was constructed from which the resistance of any one coil at a temperature between these limits can be determined. On this chart a curve is drawn for each coil; the ordinates of this curve represent the resistance, while the abscissæ give the temperature. The temperature at which the various resistances were originally each one B.A. unit are known for the representative coils. For these temperatures the ordinates of the curves drawn ought to be the same, and the corresponding resistances one B.A. unit. Mr. Fleming finds, however, that this is not the case. The resistances of the eight coils examined at the temperatures at which they were originally said to be correct are slightly different. The greatest difference is that between the coils marked *c* and *b*, and amounts to ·0011 mean B.A. units.

The mean of all these resistances at the respective temperatures is taken as the mean B.A. unit, and is that to which the resistance coils for testing are referred.

The coils examined are those marked as below in previous reports:—

A	B	C	D	E	F	G	Flat	1876
2 ...	3 ...	58 ...	35 ...	36 ...	29 ...	43 ...	Flat ...	1867

In comparing the single unit coils the forms of resistance bridge devised by Mr. Fleming, and described by him (*Proceedings* of the Physical Society), is employed.

The bridge, with battery keys and a suitable galvanometer, is permanently fitted up in a ground floor with a north aspect. The standard coils are kept in a case in the same room, and the baths in which the coils are to be immersed are always ready, filled with water, which is thus at the temperature of the room. When a coil is to be tested a suitable standard is chosen, and the two are placed in the water baths, and left for at least three or four hours, more usually overnight.

The comparison is then made in the ordinary manner by Carey Foster's method (*Journal* of the Society of Telegraph Engineers, 1874), and the coils again left for some time without being removed from the water. After this second interval another comparison is made. The temperatures of the water baths are taken at each comparison, and, as a rule, differ very slightly.

We thus have two values of the resistance of the coil to be tested at two slightly different temperatures.

The mean of these will be the resistance of the coil in question. At the mean of the two temperatures we are thus able to issue a certificate in the following form:—

"This is to certify that the coil No. X. has been compared with the British Association's standards, and that its value at a temperature of a°C. is P. B. A. units or PR-ohms, 1 B. A. unit being ·9867 ohm."

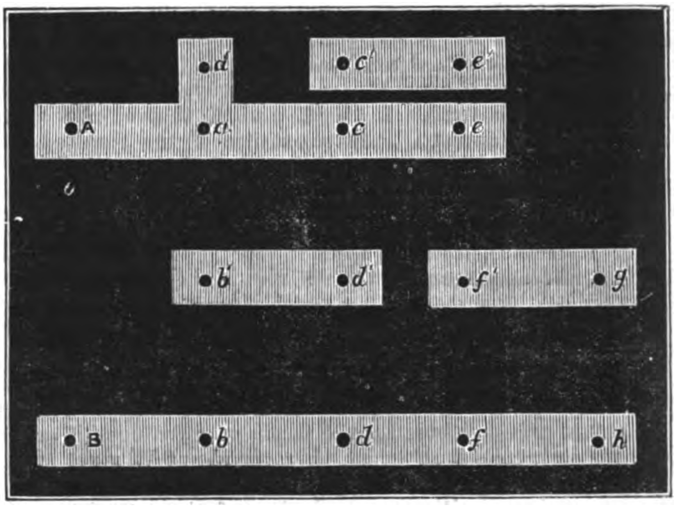
We further propose to stamp all coils in the future with the monogram and a reference number.

One single unit coil by Messrs. Latimer Clark, Warden, and Muirhead, three by Messrs. Elliott Bros. for Professor Mascart, and one by Messrs. Simmonds and Company have been tested. It will be noticed that nothing is said about the temperature co-efficient of the coil, or the temperature at which the coil is accurately 1 B. A. unit.

To determine this exactly is a somewhat long and troublesome operation, but at the same time it is one which every electrician, if he knows the value of the coil at one given temperature, can perform for himself with ordinary testing apparatus. It does not require the use of the standards. For many purposes the approximate value of the temperature co-efficiency obtained from a knowledge of the material of the coil will suffice. We may feel certain that any one requiring accuracy would be quite able and would prefer to make the measurement himself. We can state with the very highest exactness that the resistance of the coil × at a temperature a° C. is R. To obtain the temperature co-efficient accurately requires an amount of labour which may be quite unnecessary for the purpose for which the coil is to be used. But it is requisite to have standards of higher value than one unit, and part of the association grant has been used in obtaining coils for a resistance of 10, 100, 1,000, and 10,000 units. Two of each value have been purchased, so that by frequent comparison of one with the other an accident to either may be checked.

It remains, therefore, to describe how these coils are to be referred to the standards. For the 10 units two methods have been adopted.

There are at the Cavendish Laboratory two five-unit coils. Each of these was compared with five single units placed in series, using Fleming's bridge to make the comparison, and the ten-unit coil was compared with these two in series.



The values obtained by two observers at a temperature of 12° were—

9·98360.................... Lord Rayleigh.
9·98393.................... Mr. R. T. Glazebrook.

For the second method suppose we have three coils, each of resistance of about three units. Let them be $3 + \alpha$, $3 + \beta$, and $3 + \gamma$, then the resistance of these three in series is $9 + \alpha + \beta + \gamma$; and in multiple arc, if we neglect terms like $\frac{\alpha^2}{81}$ &c., it is $1 + \frac{1}{9}(\alpha+\beta+\gamma)$. Thus, neglecting such terms as $\frac{\alpha^2}{9}$, the resistance of the three in series is just nine times that of the three in multiple arc.

But these three coils in multiple arc are very nearly one unit, and can be compared with the standards. If, then, we combine in series with the same three one of the standards, we have a resistance of approximately ten units, whose value is very accurately known, and with which any other ten units can be compared by the aid of Fleming's bridge. Lord Rayleigh has devised an arrangement of mercury cups by means of which the changes indicated can be easily performed.

The three-unit coils are wound on the same bobbin and enclosed in the same case. The six electrodes project in pairs, and their ends lie in one plane. The above figure re-

* British Association, Southport Meeting, September, 1883.

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presents a piece of ebonite, through which holes are cut, as indicated by the letters *a*, *b*, &c.

On the under side of the ebonite strong strips of copper with their faces well amalgamated are screwed, forming with the holes in the ebonite a series of cups, which are filled with mercury. The copper strips are cut, as shown in the figure, to make the necessary connections. The distances between the holes are such that the electrode of the three coils respectively fit into *a b*, *c d*, and *e f*, or with *a'b'*, *c'd'* and *e'f'* connection is made with the bridge by means of the cups A B, while the electrodes of the second single unit coil fit into *g* and *h*. In the first position the three coils are in multiple arc, as will be seen from the figure, and can be compared with a single unit, while in the second they are in series with the other single unit, and can be compared with the ten units.

By this contrivance the ten unit is referred to the single standard. To determine the value of a coil of 100 units the three 3 units can be replaced by three 30 units and the single unit by 10.

This, however, is not the most convenient method, for the total resistance of the wire of the Fleming bridge in use is only $\frac{1}{20}$ of a unit, thus affording too small a range for the ready comparison of large resistances. The following has been adopted:—Four coils are arranged as in a Wheatstone bridge, one being the 100 units to be tested, of the others in opposite arms, two known ten units, and the fourth a known single unit.

These coils are all arranged in the same circular trough of water, and their electrodes dip into four mercury cups. If all the coils are correct no current will traverse the galvanometer. Of course, in practice this condition is never realised, either one of the ten units or the single unit is too great. Let us suppose it is the latter. Connect its two electrodes with the two electrodes of a resistance box, and take out plugs from this till a balance is secured. Then, if the resistance of the ten units be Q, and R that of the single unit S and the shunt W, the resistance of the shunted arm is $\frac{W S}{W + S}$, and that of the 100 units is $\frac{Q R (W + S)}{W S}$.

Now, in practice if Q R S are fairly accurate, W will be a large resistance, and an approximate knowledge of W will suffice. W may thus for all we require be taken from a resistance box by a good maker which has stood for some time in the room in which the experiments are conducted, the temperature being taken as that of the room. A box has been ordered from Messrs. Elliott Brothers for this and similar purposes. The same firm have also supplied a high resistance galvanometer for the testing. Of course, if one of the ten-unit coils is so great, then the shunt W must be put in with it.

In accordance with the resolution of the committee a fee of £1 1s. has been charged for testing single units, and of £1 11s. 6d. for others.

The only coils the testing of which is regularly undertaken are single units and multiplies of single units by some power of 10.

But though this is so two standard ohms have been ordered, using for the value of the B. A. unit ·9867 ohm, and when they arrive and have been tested it will be easy to determine the value of coils which do not differ much from a real ohm. At present without these standards the coils actually used in the recent experiments at the Cavendish Laboratory have a resistance of about ·1, ·24, and ·158 ohms. The operation is troublesome. The simplest accurate method seems to be to combine in multiple arc the real ohm and one of the 100 B. A. unit standards, and to compare the combination with a single unit. Dr. Muirhead also reports the completion of three air condensers as standards of capacity.

The committee are glad to learn that Lord Rayleigh is continuing his valuable researches at the Cavendish Laboratory with the view of obtaining an absolute unit of current.

They would ask in conclusion that they may be reappointed, with the addition of the names of Mr. H. Tomlinson and Professor W. Garnett, and that a further grant of £100 may be made to meet the expense of procuring standards of resistance in terms of the ohm.

CORRESPONDENCE.

(Translation.)

NEW UNIPOLAR DYNAMO.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In the issue of your journal for September 1 ("Notes"), p. 363, under the title of a "New Dynamo," you give an extract from the *Scientific American* describing a new and somewhat remarkable electrical machine, which is the invention of Mr. A. Floyd Delafield, of Norton, America.

Here we have in very truth an electro-motor without wire that can be subject to induction in the magnetic field (*sans fil de l'induit dans le champ magnétique*). I ask, what does Mr. Gisbert Kapp think of it—he who intervened with so much warmth sometime since, to prove with reference to this arrangement, which I had pointed out as offering a possible solution of the problem, that such an idea was electrical heresy? Now, here we have a similar expression, or thereabouts, viz.: "armature without wire," and, since the *Scientific American* describes the machine, we may suppose that it exists and will work.

However this may be, it is certainly not enough to publish a new idea, and the simple enunciation of a principle differing from that which is generally accepted gives no actual right to the person laying it down. The merit is conferred, on the contrary, on him who can carry out the principle, and Mr. Floyd Delafield appears to have been the first to do this. But I have to reproach myself at present with having taken too great notice, perhaps, of the criticisms of an eminent man, no doubt, but who may deceive himself once in his life.

In point of fact, the machine at which I have been working for some time, and the definite arrangement of which is from the present time put a stop to, has many points of resemblance with that of which you give a short description. The same distinctive characters are to be found in it, but there is an essential difference of principle in the mode of receiving the current at the machine and of conducting it away. The ideas that I have been working out relate chiefly to a receiving machine, that is to say, an electro-motor.

In the letters which I have had the honour to send you, I have expressed my opinion on the subject of the modifications which should be introduced into the construction of electrical machines. I foreshadowed a radical revolution in the principles upon which we have worked up till now. Particular circumstances have prevented my being more precise as to the alterations which I foresaw. Now that the *Scientific American* has spoken, I am no longer restrained by the same reserve, and I will give you an idea of the system to which I have been led.

The modifications which I have always had in view relate particularly to the method of receiving the current at the motor, as well as to the means for avoiding reversals of magnetic polarity, by insuring perfect continuity of the circuit. Yet another question has occupied my thoughts, viz., the differential carrying forward of the magnetism which takes place in the elements of a soft iron ring covered with copper wire, as in the case of ordinary dynamos. I treated of this matter in my recent letter dealing with the phenomenon of induction which takes place in the Griscom motor (vide *Electrician*, Sept. 8, p. 400). Whatever value may attach to my explanation, one thing appears to be certain, viz., that as machines are actually constructed, it is impossible to collect the entire sum of the inductive actions which take place in the wire and in the core, and that it would be in all respects advantageous that the points of maximum induction in the two parts of the ring should correspond.

The conditions laid down—as well as that relating to the suppression of reversals of polarity—can be realised by causing a Siemens bobbin to revolve inside a fixed Gramme ring, in which the poles alter their position, section by section, those of the bobbin remaining unchanged. They can also be obtained, other things being equal, when one of the portions of the ring—the cylindrical core—alone is caused to move, and is set in motion under the combined

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action of the ordinary inducing poles and the two poles created in the soft iron by a fixed solenoid.

Such is the double solution which I have seen fit to adopt, and in searching for which I have been helped by Mr. Max Rumberg, electrician, of London. The motors which we have adopted are characterised by the complete suppression of rubbing brushes and a collector. The cylindrical core of the armature alone is movable, and revolves with a regular and continuous movement between the cheeks of the inducing electro-magnet, owing to the very complete continuity of the current from the generator. The magnetic poles excited in the core by the circular solenoid remain fixed in space; they are displaced in the soft iron forming the cylinder. The position of these poles in relation to those of the inducing electro-magnet remains therefore constant; it is so determined that during the period of rotation there is a maximum of attraction and repulsion.

The principle determining the rotation is therefore nearly the same as that in Mr. A. Floyd Delafield's machine. The two auxiliary poles set up by the circular magnet react on the poles of the inductors and give rise to a magnetic field, which surrounds the armature externally. The current from the machine is uniform and continuous, and there are naturally no reversals of polarity, and sparks are no longer produced, since the collector is done away with as well as the rubbing brushes.

Meantime, I must say that I cannot understand how the current is led away from Mr. Delafield's machine. From what I have gathered from the description, I am lead to suppose that here we differ essentially in principle. To put it shortly, I do not like, either from an electrical or mechanical point of view, contact springs; they are never certain. Again, I should have preferred an arrangement by which the motive current entered by a fixed auxiliary coil, contrary to that adopted by Mr. Delafield, which appears to consist in running a circuit into his tubular armature itself, in order to polarise it. He would certainly do away with a commutator by this means; but he would always have a continuous collector, and the current would be interrupted here.

Our machine has been designed, but has not yet been tested. The results on both sides have therefore to be awaited.

Later on, machines will be constructed, without doubt, on this principle, without cores that can be subject to induction and electro-motors without wire in the magnetic field that can be subject to induction.—Yours, &c.,

ALBERT BANDSEPT.

THE RYSSELBERGHE EXPERIMENTS IN BELGIUM.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In the interesting note on the International Electrical Exhibition at Vienna which you publish in No. 19, p. 447, of your valuable journal, we read the following:—"The most important fact about the Antwerp-Brussels experiment is that it is one of a number of experiments to utilise the ordinary telegraph wires for telephonic purposes without interfering with the telegraphy."

We beg to point out a slight mistake. The experiments were not carried out with ordinary telegraph wire, but with phosphor-bronze telegraph wire of our manufacture, attached to the ordinary telegraph poles.

We hope you will kindly give space to this in your next issue.—Yours, &c., J. MANNE, Manager.

415, Chaussee de Mons, Anderlecht-lez-Bruxelles.

THE INVENTION OF THE TELEPHONE, AND AN EARLY ELECTRIC CLOCK.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In your issue of September 22nd I see a suggestion as to priority of invention of the telephone, which is claimed for Bourseul, 1854. The enclosed may be interesting:—

Family Herald, August 8th, 1846. Speaking telegraphs. "A gentleman in Charleston has invented an electric telegraph to communicate by sounds; it speaks the letters instead of writing them. It requires twenty-seven wires, one for each letter, and one to give the electric power (?). M. Faber's wonderful speaking automaton with one of these machines could give us the news by telegraph from Washington in conversation.—*American Paper*."

Do you also know anything of this cutting from *Family Herald*, April 10th, 1847: "Mr. Bain, according to the *Ipswich Journal*, is about to erect his electrical clock in the tower of Wenham Church, with power of motion to be incessantly maintained by a perpetual current derived from the earth."—Yours, &c.,

Great Marlow. W. WRIGHT-NORTH.

THE LATE MR. WERDERMANN.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Your short but truly appreciative article on the late Mr. Richard Werdermann will be read with great interest by all who knew him personally, or are connected with the progress of electrical science. It is an able summary of the principal events in his career as an electrician, and justly estimates his personal qualities. But you have omitted to mention a few facts which I think should not be forgotten.

Some years ago Mr. Werdermann exhibited from one of the towers of the Houses of Parliament a powerful arc light, the current for which was supplied by a Gramme machine. This was one of the earliest illustrations of the practicability of electrically lighting large areas from a central point, and of the efficiency of the Gramme machine for this purpose.

With regard to the inventorship of the electric candle Mr. Werdermann had undoubted priority; and had he been keen in the assertion of his rights as a patentee, that form of light would probably have been known as the "Werdermann," instead of the "Jablochkoff" candle.

In addition to the inventions which you have mentioned, and others relating to various subjects, Mr. Werdermann, at a date prior to the introduction of those systems now before the public, had designed and patented in this and other countries a system of electrical propulsion of railway vehicles, and had he been more fortunate in his business connections, these inventions, which afford another example of his originality, would have advanced by a great step the progress of this branch of electrical engineering.—Yours, &c.,

8, Southampton-buildings, W.C., WM. ROBT. LAKE.
Sept. 20, 1883.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Will you kindly permit me to make use of your esteemed journal in order to bring before the notice of its readers a matter which I trust may enlist the sympathies of those—and the number must be many—to whom the late Mr. Werdermann was known. May I add to your kindly notice of his life and labours (published in your last week's issue) that, like many inventors, Mr. Werdermann has, so far as can be seen prior to the complete investigation of his business affairs, left his family entirely destitute. I became acquainted with Mr. Werdermann almost immediately he took up his residence in London, and I had the privilege of assisting in nearly all his experiments, including those you mention, till the year 1879.

I remember well the numberless tests which were made with electric candles, electric furnaces for melting refractory materials, and electric brakes for railways; the attempts to employ "Serrin" arc lamps—the only kind to be obtained at the time—in series, and in parallel circuit; experiments on the electrical transmission of power, which were very fully carried out; the semi-incandescent lamp, which had a curious origin; and also experiments on many other subjects which would occupy too much of your valuable space to recount.

On the grounds, therefore, of Mr. Werdermann's long and useful connection with electrical science, I beg leave, with your permission, to state that it has been decided to open a subscription list to alleviate the immediate and pressing necessities of the Werdermann family, and that cheques or Post Office orders from the charitably disposed will be thankfully received and acknowledged by Alabaster, Gatehouse, and Co., 22, Paternoster-row, London, E.C.—Yours, &c.,

T. E. GATEHOUSE.

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THE ELECTRICIAN.

TO CORRESPONDENTS.

All letters intended for insertion in The Electrician, *or containing questions, must be accompanied by the name and address of the writer not necessarily for publication, but as a proof of good faith. No notice whatever will be taken of anonymous communications.*

All communications to be addressed to 396, *Strand, London, W.C.*

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THE BRITISH ASSOCIATION.

The meeting of the British Association at Southport has come and gone, and in more ways than one the occasion will be remembered. Southport is a comparatively new watering place, as ambitious as are all such places, said to be wealthy, and therefore anxious to play the part of patron to science. The inhabitants of Southport will not hear a word against the town of palaces, as one local guide calls it. Nor do they accept it as a reproach that the "sea" is so distant. Sometimes the sea actually comes as far as the promenade, and, though seldomer, when wind and tide agree, the water is even known to dash upon the promenade. The picture we have carried away from this place is one of a town built upon levelled sandhills, a foundation excellent sanitarily, and where very large sums of money, combined with a fair modicum of brain power, have been used in work to render the town attractive. Gardens have been formed upon the sand heaps till one is apt to think that the English, when they have a mind to, can emulate the Dutch in reclaiming waste places. Southport has welcomed the British Association for the first time; the local authorities and the residents have striven heartily to make the meeting successful, and so far as mere numbers are concerned have reason to know that their efforts have not been in vain.

The recent meeting has, indeed, attracted more members than any of late years; in fact, the attendance has been exceeded in only one or two instances. Although the attendance has been so good, it would be a gigantic stretch of the imagination to say as much for the "science." The papers read may have been as numerous as usual, but few of them contained even a germ of aught that was new, many were too much after the fashion of trade advertisements, and others the result of political-commercial speculation. Science has, however, a fair sprinkling of votaries who have yet to learn some of the many phases of the wire pulling which performs so great a part in the history of mankind. But, after all, who expects that science will be the prominent feature at a British Association meeting? The major portion of the members agree that the work of such a meeting is more to put forward scientific truths in a popular manner, so that the masses can understand—and understanding support; that too high a strain is altogether out of place, and that scientific fanatics should be relegated to the platform of the Scientific Society, and not air their pet theory or describe a long list of experimental details to a mixed assemblage. When it is known that from eight hundred to a thousand lady members joined the association at Southport, this view may be accepted as founded upon sufficient data.

We must confess that we prefer to look upon such gatherings in this light. The papers to be read bring the members together. Little notice is at the moment paid to some of the papers, which, however, being reported, and hence preserved by the technical journals, are by no means without value. Accepting the fact that a good deal of popularity has crept into the sections, and accepting at the same time that this is merely an example of the survival of the fittest, we would urge upon the members and friends of the association to make a strenuous effort that next year when the association meets in one of our great dependencies the "science" shall be worthy of England. It is useless for the executive to leave things to chance; they must bring influence to bear upon our foremost men of science, and seek that they shall prepare papers upon the subjects they make a speciality. Let all branches of science be represented, each by the ablest and worthiest representative that England can find. Canada offers a hearty welcome. The association commences a new era in meeting outside the bounds of Great Britain, and invites Greater Britain to knit still closer the ties that bind together the scientific worthies of the English speaking race. The mother country should show these scions of hers that she is still able to take her place in the forefront of progress, and if, on the one hand, hospitality is offered, on the other the best that science can give should be freely given. Ten months may seem ample time to make arrangements, but we fear it will be found all too short, and that, unless immediate steps are taken in the direction indicated, the best will not in every case be obtained.

We shall in due course give, either wholly or in abstract, the papers which have been read at the recent meeting, and it will be seen that these papers do not adequately represent electrical science in England. No doubt we ought to expect a lull in research in this direction, just the same as we expect periodic maxima and minima in sun spots, and the public mind is not so deeply agitated just now as it was a year or two since. A paper on the Portrush Electric Tramway was down for reading, but owing to want of time was not read. Mr. Holroyd Smith, however, described the experiments he has been carrying out at Halifax, but otherwise the great subject looming before electricians of the transmission of power remained unnoticed. It seems to us that the experiments of Deprez and

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others might well have been considered, as well as the theory that underlies the electrical transmission of power and the utilisation by electrical apparatus of the natural forces now being wasted. Perhaps the visit to Canada, and the nearer consideration of the water power there running to waste will prove an incentive to the writing of a valuable paper on this subject for the meeting of the year 1884. Another subject we had hoped to have heard discussed is that of the proportioning of the parts in dynamo machines. Improvements by Dr. Hopkinson, Mr. Edison, Mr. Crompton, and others have been introduced during the past year, but of the theory underlying this proportioning of parts we know little, and surely this might form a good subject for investigation by such eminent mathematical physicists as adorn Section A.

THE INTERNATIONAL ELECTRICAL EXHIBITION AT VIENNA.

(FROM OUR SPECIAL CORRESPONDENT.)

IV.

It is necessary to mention that your engraver has transmuted the sketch of the Thunder Pump into a piece of apparatus such as exists neither in the exhibition nor in any other place upon the earth's surface. The sketch sent was, perhaps, not very neatly drawn, but at any rate the correct position of the parts was indicated; for instance, the coils should be shown upon the poles of the magnet, and not around them. However, mistakes will arise, and readers must wait for another illustration before they will gain any idea of how the thunder pump is constructed.

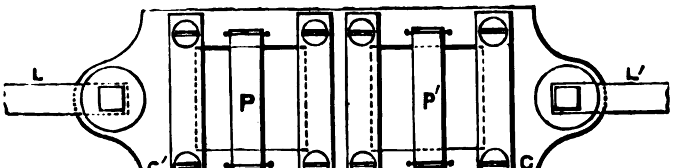

Fig. 1.—Hedges's Duplex Cut Out.

Mr. Killingworth Hedges exhibits a number of cut outs with albo foils. This name albo is given to the alloy of aluminium and tin, which is used for the fusible portion.

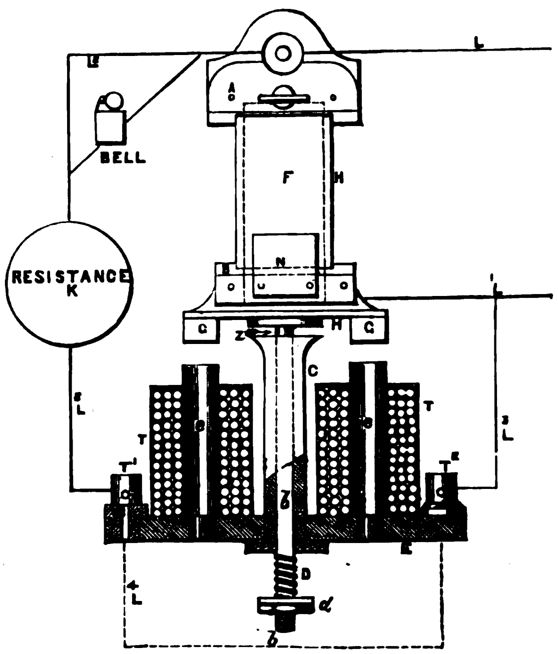

Fig. 2.—Hedges's apparatus for Completing Circuit when a Cut Out is Fused.

The following is a list of the widths of foil used for different currents. The thickness is the same for all sizes. For greater currents than 100 amperes a double strip is used:—

Width of strip millimetres.	Fusing current, amperes.	Width of strip millimetres.	Fusing current amperes.
10	30	18	62
11	34	19	66
12	38	20	70
13	42	21	75
14	46	22	80
15	50	23	85
16	54	24	90
17	58	25	100

Fig. 1 shows a new form of duplex electrical cut out. L and L′ are the main leads of a circuit of lamps. The current passing from machine, enters at L, passes through the fusible foil P, through the lever H out at L′, through the lamps and back to machine. Should plug P, by excess of current or short circuit, fuse, then the lever H is switched

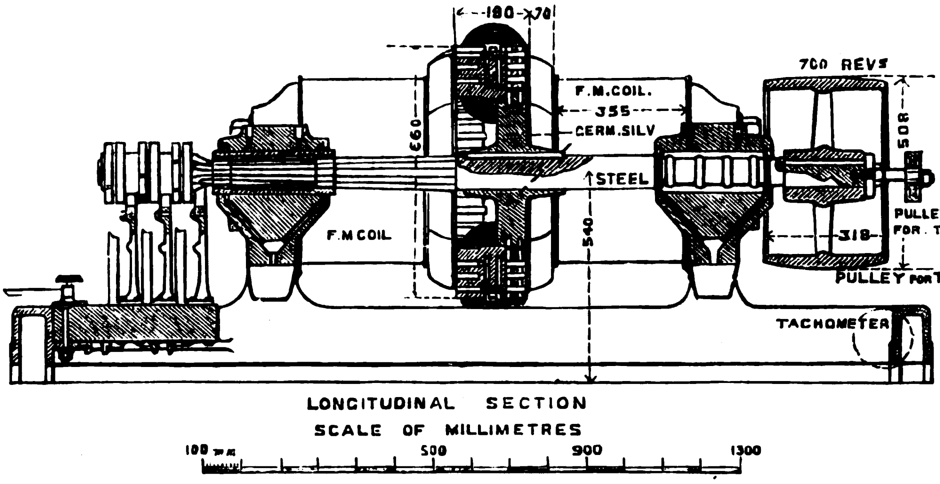

Fig. 3.—Sectional view of Brush Machine. (For description see next page.)

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over from C to C', thus completing the circuit through P', and at the same time putting in the other fuse P', and the fuse that went at P can be replaced at leisure. This duplex cut out is made of iron, is very strong, and is specially applicable to engine rooms or places where it is likely to meet with plenty of rough usage. It has been tested with the

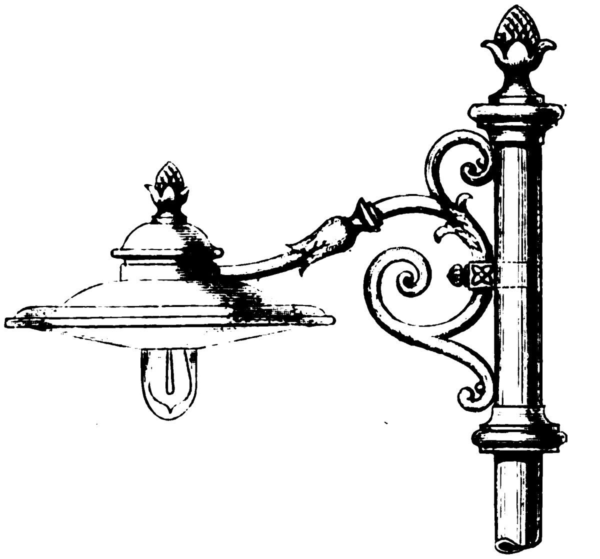

Fig. 4.—Ornamental Post and Bracket for Incandescent Lamps.

most satisfactory results, and is made to take currents of any quantity.

We now pass on to an arrangement to be used with the before-mentioned cut out, which is shown in action at the exhibition. It has for its merits the means of completing a circuit on the fusion of a cut out; and, at the same time,

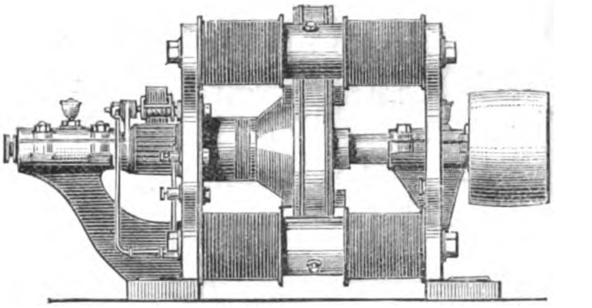

Fig. 5.—Front view of Schuckert-Brush Machine.

ringing a bell, thus giving an alarm to the attendant, also of putting resistance into the main circuit. L and L' (Fig. 2) are main leads, the current passing along L, through the fusible cut out F. Now, should F be fused through excess of current, or short circuit, the current will pass through the resistance K, round the electro-magnets *e e*, which in their turn

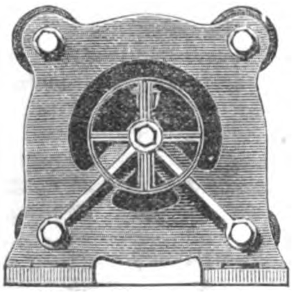

Fig. 6.—End view of Schuckert-Brush Machine.

tightly hold down G G, and the current will pass through L', thus forming a shunt circuit through the resistance K, and ringing an alarm bell B. By joining the magnet F can be switched out and a new foil inserted. Another exhibit is a switch, in which, by pressing a stud, the contact piece, under the action of a spring, flies back, and the circuit is broken.

There is a large assortment of all descriptions of Hedges's patent switches. We are told that forty of these switches have been selected by the scientific committee for use in the testing room attached to the exhibition. An assortment of carbons by the Barnsley Carbon Company, of Barnsley, are are also exhibited, consisting of rods of various sizes for electric lighting and plates for batteries. The consolidated plates are said to be of great density. They have holes punched at the top, to avoid the trouble of extra boring to fix the connections.

In addition to our former remarks upon the International Electrical Company's exhibit, we are able now to give (Fig. 3) a sectional view of the No. 8 Brush machine. The figures given are in metric measures, otherwise the illustration explains itself. The incandescent lamps lighting the road leading from the entrance of the exhibition through the Prater to the town are placed upon posts about the height of ordinary gas lamp posts, and the light from the incandescent lamp is all thrown downwards by means of a reflector. The upper portion of the post, with lamp and reflector, are shown in Fig. 4. The design is very neat, and the apparatus answers well the purpose for which it is intended. Figs. 5 and 6 show the modified Schuckert shunt wound machines used in this installation. The ordinary Schuckert machine is so well known that we have merely to say that the principal modifications are in the size of wire used in the winding, and the introduction of a second magnet.

TELEGRAPHIC INTER-COMMUNICATION.*

BY W. H. PREECE, F.R.S.

The introduction of the A B C instrument by Wheatstone, in 1858, provided the trading community and others inexperienced in the working of the usual class of telegraphic instruments with a convenient means of establishing communication between their various places of business and their homes which they could work themselves. A little index is worked by electric currents step by step around a dial, on which the letters of the alphabet are written, and it dwells for an instant opposite the letter required to be indicated. The manipulation of this apparatus is so simple that a few minutes' instruction is sufficient for the most unskilled to acquire a knowledge of its working. The index being propelled by magneto induced currents, has the great advantage of being independent of batteries, and it is therefore the most useful form to employ for establishing public communication with distant villages and outlying districts, where the message traffic is not great, and where skilled operators are not available. For this purpose it is very largely used in the Post Office service. The Universal Private Telegraph Company was formed in 1861 to manufacture and supply this instrument to the public. A branch of the company was established in Newcastle-on-Tyne, where, in 1864, an exchange was formed to facilitate the inter-communication between the different users of the system themselves. It commenced with three renters, which had increased to eight in 1870, when the telegraphic system of the country was transferred to the Government. The company also erected private wires, a business that has been continued by the Post Office. In 1875 there were about a dozen such private wires, either terminating in the Newcastle Post Office or passing through it from one works to another, or from the works to the offices of a firm, and there were many additional circuits connecting the outlying portions of coal and iron companies' estates with their head offices. The system had increased so rapidly, and the desire for inter-communication became so general, that a switch for 60 renters was fixed in March, 1878. It was of the usual combination of insulated brass bars arranged to cross each other at right angles, and connected together at pleasure by means of brass plugs, so that any renter could be first connected to the instrument at the Post Office to communicate his wants, and, if necessary, afterwards plugged through to any other renter.

* Paper read before Section G, British Association, Southport Meeting, September, 1883.

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Figure 1 shows two renters plugged through to each other, and one connected to the instrument for sending or receiving a telegram, the fourth being in the normal position.

The apparatus used at the switch station for denoting the calls consisted of indicators and bells. Electric inter-communication soon, however, became further developed by the introduction of the telephone. With this instrument the somewhat tedious operation of spelling out one's messages letter by letter was replaced by the more rapid process of reproducing human speech.

The first switch for telephonic inter-communication in the Newcastle-on-Tyne district was fixed in the Newcastle office in May, 1882, the new system being at the commencement confined to the town itself; but it very rapidly extended, and now embraces the whole of the outlying manufacturing district. It has, however, by no means caused the abolition of the former system, the A B C being still considered by many renters a more reliable instrument for long circuits and for the transmission of important messages. Moreover, it

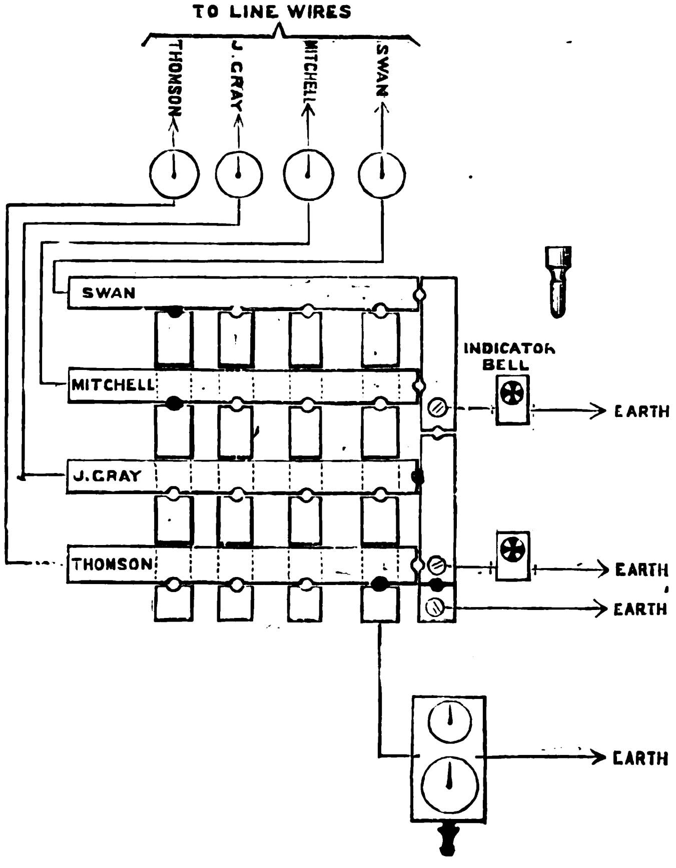

Fig. 1.—Switch for use with A B C Instrument at Newcastle.

is not affected like the telephone by the induction from other wires. Overhearing is impossible, and absolute secresy maintained.

The wires of the A B C and the telephone systems and the ordinary telegraph wires are run together in the same pipes underground and on the same poles overhead, but in order to overcome the induction from the strong currents used on neighbouring telegraphic circuits and the disturbances due to the use of the earth as a return, it was found necessary to dispense with the earth altogether, and make the telephonic circuits metallic by using return wires, the two wires, whether on the poles or in the pipes, being always twisted around each other, whilst the ordinary telegraphic wires are run parallel as usual.

For underground telephone circuits the wire used is No. 21½ copper B. W. G., covered with gutta percha to No. 10¾. Each cable consists of four such wires simply twisted together, each diagonal pair of wires being selected to form a circuit. Where the wires are erected on poles along with other wires a complete twist is formed between every five poles, and unless the insulation becomes very imperfect there is no disturbance of any kind, and the telephones are quite silent.

The Gower-Bell telephone is the instrument used throughout the postal system; it has undergone considerable improvement since its introduction, the result principally of greater care in the details of manufacture.

In any inter-communication system prompt attention is essential; the switch clerk should be able to know the condition of every wire; he should see whether it is engaged or disengaged, and he should have instant knowledge of the cessation of conversation. These points are obtained by using permanent currents on each wire. The subscribers instead of being furnished with the usual ringing battery used on the open circuit system are provided with a sufficient number of Daniell cells to give a current sufficient to safely hold up the shutter of the indicator at the exchange. To call the exchange the subscriber breaks this current, either by pressing the push piece of the telephone or by simply placing the hearing tubes of the instrument to his ears. The breaking of the current causes the shutter of the indicator to fall, and thus attracts the attention of the switch clerk.

Playing between the poles of the electro-magnet that holds up the shutter is a small magnet or index, which, by its deflection, shows that the current is flowing. The construction of the indicator will be understood on reference to Fig. 2. *e e'* are ebonite collets passing through the metal base of the instrument, through which pass the screws which join the ends of the coils to the connection plates at the back of the indicator tablet. *i*, in the figure, is an insulated stud by

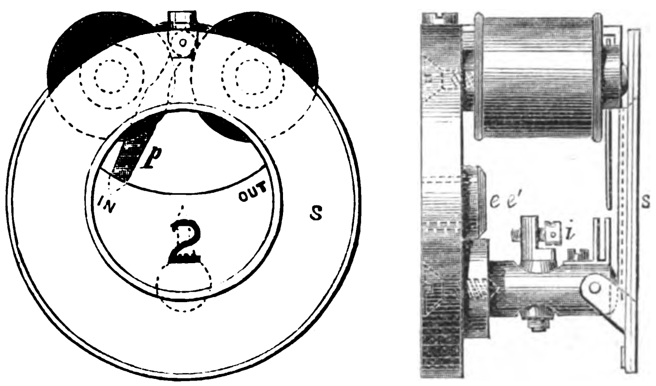

Fig. 2.—Telephone Indicator for Permanent Currents.

which, when the shutter falls, a local bell circuit is completed. The shutter (*s*) has a hole in the middle, thus exposing the name plate, which is fixed in a rack behind the shutter. This name plate does not quite cover the hole, but leaves a space through which the direction of the pointer (*p*) can be seen.

The diagram (Fig. 3, p. 472) is a plan of the cabinet adopted for mounting the switch and indicator tablets, and the necessary speaking apparatus. The brass plug holes are provided in groups of 25, 50, or 100, according to the probable ultimate size of the exchange. The indicators are attached as required. Each hole of the switch board is formed of two brass springs, which are normally in contact. To the upper spring the line, or No. 1 wire, is attached, the return, or No. 2 wire, being connected to the lower spring. The indicator is invariably placed in No. 1 wire. The upper brass piece of the hole is slotted, and the upper portion of the connecting plug is provided with a projecting piece, which fits the slot so that the relative sides of the plugs are always correctly inserted between the springs. This is necessary, as the wires of the flexible cord which connects the switching plugs together must always be crossed, so that when two renters are connected, No. 1 wire is in both cases connected to No. 2, and the indicators are thus placed relatively in the same positions in the circuit, and balance each other. If this device were not resorted to the wires would be joined straight through, both indicators would be in one wire, the balance would be disturbed and induction set up.

The method of working both the A B C and telephonic systems of inter-communication is identical. One subscriber

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desiring to communicate with another calls the switch office (or exchange) and intimates with whom he wishes to correspond. The two wires are then connected. In the case of the A B C, the indicators at the switch office work in unison with those at the renter's offices, and the switch clerk is enabled by simply watching them to ascertain when communication is finished. He then restores the wires to their normal positions, without further reference to the renters, by removing the connecting plugs.

Similarly with the telephone, a subscriber desiring to converse with another signals for the attention of the exchange by dropping the shutter of the indicator connected with his line. The switch clerk ascertains with whom the renter wishes to correspond, and the two lines are then connected. The termination of communication is automatically announced to the switch clerk at the exchange by the deflection of the needle. At every renter's office the telephone is arranged so that the " holders " or " rests " in which the ear tubes are hung act also as switches, by means of which the battery which sends the permanent current is connected to, or disconnected from the line. When the renter has the tubes placed to his ears the permanent current battery is switched out of connection with the line, the shutter of the indicator at the exchange falls, and remains unattracted, and the needle hangs vertically. When the tubes are restored to their holders a current flows through the line and indicator, and the needle is deflected, indicating to the switch clerk that communication is closed. The wires are then separated by the restoration of the switch connections to the normal position.

A simple commutator or switch at the renter's office enables him to indicate whether he is "in" or " out." This reverses the direction of the permanent current, which reverses the deflection of the needle, and so indicates to the switch clerk whether the renter is in his office or out of it. By means of this system of indication calls are distinctly recorded at the exchange and prompt attention secured, and where one subscriber desires to speak to several others in succession the connecting and disconnecting of the various wires is rapidly effected, and economy of time secured.

The telephonic and A B C systems are also worked conjointly in the following way:—Telephone renters who require inter-communication with subscribers connected to both systems are provided with two instruments, a telephone and an A B C. At the renter's office a switch is fixed, arranged in such a way that either instrument may be used at will, one of the telephone wires being connected to the A B C, the second (or return wire) and the telephone instrument being thrown idle during the time the A B C is in use. At the Telephone Exchange a similar method is adopted by which the wire used for A B C working is diverted from the telephone to the A B C switch. Telegrams also pass free of charge between renters connected to one or other of the two systems, such messages being transcribed by clerks provided for the purpose at the switch office, and transmitted from subscribers' offices connected with one system to the offices of subscribers connected with the other system.

The Telephone Exchange at Newcastle-on-Tyne opened with a list of thirty-two subscribers. The average number of exchanges of inter-communication at the commencement was thirty-five per day, and the number of messages transmitted per day at the outset averaged eleven. At the present time the number of telegrams dealt with per day averages 210, whilst the number of exchanges of inter-communication per day averages 2,200.

The number of offices connected with the exchange has increased correspondingly, and the list of subscribers now includes the names of 333 firms and individuals. The requirements of these subscribers demanded that the system, to be complete, should afford facilities for direct communication with the neighbouring towns, and in April of this year a trunk line formed by two wires was opened between Newcastle and Sunderland, by which renters in the two towns were enabled to communicate with each other. One circuit, however, speedily proved inadequate, and two more have been erected, in addition to which a trunk wire to South Shields has also been opened. The system when complete will provide the means of inter-communication between Newcastle and Sunderland, between Newcastle and South Shields, between Newcastle and Tyne Docks, between Newcastle and North Shields, between Newcastle and West Hartlepool, between Newcastle and Middlesbro', between Sunderland and West Hartlepool, between Sunderland and Middlesbro', and between Middlesbro' and West Hartlepool. Thus, whilst the telephone has found many friends, the A B C has lost not a few, the average number of telegrams dealt with per day on the latter system having diminished to twenty-five, there being a corresponding diminution in the number of inter-communications, which now average only twenty-eight per day.

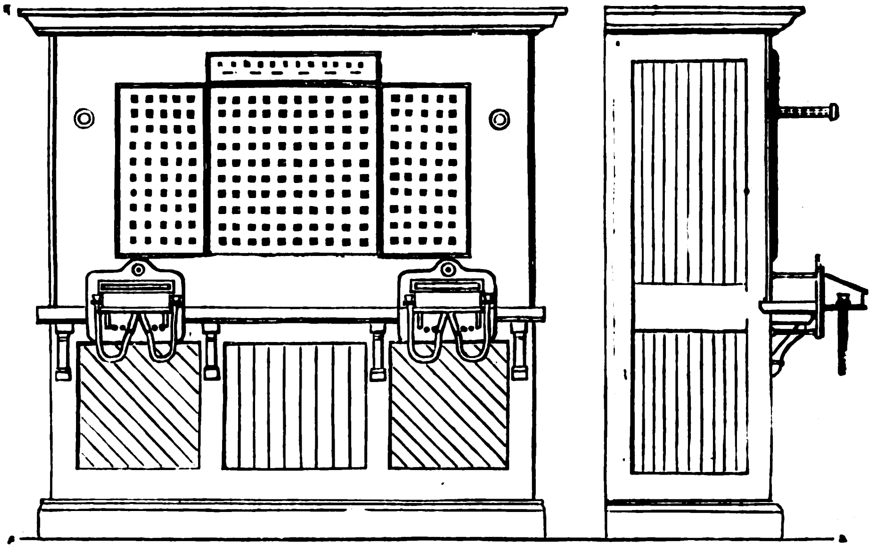

Fig. 3.—Cabinet adopted for Mounting Switch and Indicator Tablets, and Telephonic Apparatus.

GALVANI AND ANIMAL ELECTRICITY.*

In these days, when electricity is commanding universal attention as a great force capable of being made subservient to humanity, it may be appropriate to consider some of the phenomena of electricity produced by living tissues and by living organs—or what is called animal electricity. We must also remember that most of the modern developments of

* Abstract of lecture delivered by Professor M'Kendrick, M.D., F.R.S., Professor of Physiology in the University of Glasgow, under the auspices of the British Association, at Southport, on the 24th instant.

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electrical science may trace their origin to the physiological experiments of Galvani, the professor of anatomy at Bologna, in 1786. Struck by the contractions of frogs' legs in the vicinity of a frictional electrical machine, he wished to study the effects of atmospheric electricity, and accordingly made his first experiment. Then he discovered that there might be a contraction of muscle on the connection of the nerve and muscle by a heterogeneous metallic arc. Then came the notion that the nerves conveyed electricity from the brain and cord to the muscles, and, following the law that the new concepts of a man of science originate from ideas of familiar things, the muscle was forthwith compared to a Leyden jar, the inner surface of which became positive by nervous action, whilst the surface was negative. Motion was caused by the irritation of a kind of discharge, the positive, internal, surface being connected with the negative, external, surface. Volta doubted this, and held that the phenomena observed by Galvani were due to very feeble currents of artificial electricity produced by the application of heterogeneous metals to the limbs of animals. In the critical inquiry made by Volta into this question, he was led to the invention of the voltaic pile, which not only for a time threw into neglect the question of animal electricity, but also was the starting point of the electrical science of the present day. In 1820 Oersted made the discovery of electro-magnetism. This led to the invention of the astatic needle (Ampère), and of the multiplier or galvanometer (Schweigger); and in 1827 Nobili constructed a galvanometer of great sensibility, by which he could reinvestigate the question of whether or not currents of electricity could be obtained from animal tissues. He found that such currents did exist, and he supposed they were due to thermo-electric action. About ten years thereafter (1837) Matteucci, of Pisa, again investigated the matter, and found that currents could be obtained from animal structures, even where all suspicion of thermo-electric or chemical action was removed. He also discovered that the interior of muscles was negative to their surface, and that it was possible to make a kind of battery of the thighs of newly-killed frogs, which could produce chemical effects similar to those caused by voltaic elements. Then came the labours of Du Bois Reymond, the present professor of physiology in the University of Berlin, which will always mark the commencement of an epoch in the history of animal electricity. Recognising that the detection of the feeble currents from animal structures depended on the delicacy and accuracy of the apparatus employed, he made many improvements in the construction of galvanometers, and in the arrangements for leading off the currents from living textures into the galvanometer. Such galvanometers must be exquisitely sensitive, and it is evident that just in proportion as they are so, so will be the difficulty of making an arrangement which will lead off any current that may exist, say in living muscles, without causing a current itself. If we apply to a bit of muscle the ends of the copper wires coming from a delicate galvanometer we either get no effect or an effect due to the action of the muscle substance, or the fluid covering it, on the copper wire. We must have some arrangement which, while touching the muscle, will not cause any chemical change in it, and at the same time will draw off into the galvanometer circuit any current that may come from the muscle itself. That is, the electrodes of the galvanometer must be *non-polarisable*, even when touching muscle. Du Bois Reymond found that little troughs of zinc, filled with a saturated solution of sulphate of zinc, fulfilled these requirements. Into these are placed bits of blotting paper, also wet with sulphate of zinc solution, and on the bits of blotting paper are placed morsels of clay moistened with saliva. When the bits of clay are put into contact so as to make a circuit, no current passes through the galvanometer. If we now take a muscle from the back of the leg of a frog, cut it across, and place it on the clay pads so that the section of the muscle touches one pad and the surface of the muscle the other, a current of electricity passes through the galvanometer, as shown by the swing of the needle. This was shown by the lecturer, a beam from a lime-light being reflected on a screen by a mirror attached to the needles of the galvanometer. It was then shown that an uninjured frog's muscle gives no current; that no current can be got from two uninjured surfaces nor from two transverse sections; but only, speaking generally, when one clay pad touches a section and when the other touches a surface. This may be called the muscle-current. A similar current, though much weaker, can be obtained from living nerve. It was also shown that when a muscle is caused to contract, as it does naturally, the so-called muscle-current is diminished; at all events, suppose the current from a muscle brings the needle of the galvanometer to a certain point, if the muscle then be caused to contract the needle will swing back to nearly its zero point. This reverse—the so-called *negative variation*—indicates that an electrical change in the muscle happens when it contracts. But by refined methods of experiment it has been shown that this change really occurs *before* the muscle contracts, that is, the change in the electrical state of the muscle is an expression of the chemical changes occurring in it, which are antecedent to the muscular movement. The lecturer further showed how it was possible to measure the amount of those changes by Poggendorff's method of compensation, by which a fraction of the current of a Daniell cell was passed through the galvanometer in the reverse direction to the muscle current. Thus, it may be determined that the electromotive force of the natural current of a frog's muscle is about $\frac{1}{8}$ of a volt. Similar currents may be obtained from nerve, although they are very much weaker. Much discussion has taken place as to what these currents really mean; but the majority of physiologists agree with Hermann, of Zurich, in thinking that the current obtained on cutting or injuring the muscle or nerve is really due to the dying of the muscle or nerve substance at the point of section, and that the so-called "negative variation" is the current indicating functional activity. That is, living substance dies at the plane of section, and in dying it acquires a lower potential than the living matter, thus giving rise to a current. Again, suppose a living muscle giving no current on stimulating it, by irritating its nerve, so as to cause the muscle to contract, a lower potential is produced at the points in the muscle where the nerve fibres end, and there is thus a negative variation. Further, it has been shown that this negative variation passes like a wave through the muscle substance, and that the wave has disappeared before the muscle contracts. If, then, electrical changes occur during the activity of muscle and nerve, it is natural that physiologists might expect to detect changes in the beating heart. This is the case. It was shown, by projecting its image on a screen, that the uninjured frog's heart isolated from the body still lives, and, whilst beating, gave with each beat an electrical variation, as shown by the swing of the galvanometer needle. The uninjured heart gives no current, but when slightly injured there is a variation in its electrical state with each beat. Then the lecturer showed that light causes an electrical change in the eye. Placing the eye of a frog in the galvanometer cushions, it was shown that there was a current passing from the cornea to the back of the eye. In the dark little or no change could be seen except what might be due to the drying of the living structures forming the eye; on allowing light to fall on the eye, there was at once an increase in the current. This continued for a time, then began to fall off, and, on light being removed, there was another increase, and then a sudden and rapid fall off. This action, first shown by Professor Holmgren, Professor Dewar, and the lecturer, showed a specific influence of light on the retina. It could not be called a negative variation. It indicated chemical changes occurring in the retina. Lastly, the lecturer showed the production of currents from the living man. Placing the hands in two vulcanite troughs communicating by platinum plates with the galvanometer, and filled with a weak solution of salt, he showed that on contracting one arm a deflection of the galvanometer needle was produced. When both arms were quiet there was no current; on contracting one arm a current was at once produced. This current the lecturer was inclined to think was due to action of the fluid on the skin, and not to currents from the muscles, and that the differences were due to differences of contact. In summing up, after a few remarks regarding electric fishes, the lecturer said that all of these electrical

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changes were really expressions of the vital changes occurring in living tissues under the action of stimuli. It was no part of the functions of nerves, muscles, or of the retina of the eye to produce currents under the action of their relative stimuli, but such currents indicated chemical changes in the organs or tissues. For example, the contraction of a muscle is a movement following or consequent upon many chemical changes, among the results of which were the production of heat and differences of electrical potential. Thus, there was no special production of electricity except in the case of electrical fishes, and possibly of some other animals. In most animals, including man, the production of currents was an incidental phenomenon indicating chemical operations and nothing more. Besides, the currents so produced were feeble and evanescent, and bore no relation to the general well-being; consequently, all attempts to influence the living body by magnets had no rational basis. The lecturer had tested this question by powerful electro-magnets, and had not been able to detect that they had the slightest influence on any vital phenomena. It need hardly be added that the so-called phenomena of animal magnetism are of an entirely different kind from those discussed. These are of a subjective character, dependent on peculiar states of the nervous system, having nothing whatever to do with electricity or magnetism, but still in a sense they are phenomena as real as those of physical science. Their subjective character, however, renders them specially difficult of investigation, and consequently they are more liable to fall into the hands of the charlatan. One safeguard against this is the recognition of what the electrical phenomena of the living body really mean, and one purpose of this lecture will be served if it shows that to detect and account for these phenomena requires the most refined methods of the physicist and of the physiologist, and that they give us only a glimpse into the intricate changes occurring in living tissue. The lecture was fully illustrated by experiments in which galvanometers of the most sensitive construction were used.

SUGGESTIONS FOR FACILITATING THE USE OF A DELICATE BALANCE.*

BY LORD RAYLEIGH.

In some experiments with which I have lately been occupied a coil of insulated wire, traversed by an electric current, was suspended in the balance, and it was a matter of necessity to be able quickly to check the oscillation of the beam, so as to bring the coil into a standard position corresponding to the zero of the pointer. A very simple addition to the apparatus allowed this to be done. The current from a Leclanché cell is led into an auxiliary coil of wire, coaxial with the other, and is controlled by a key. When the contact is made a vertical force acts upon the suspended coil, but ceases as soon as the contact is broken. After a little practice the beam may be brought to rest at zero at the first or second application of the retarding force.

This control over the oscillations has been found so convenient that I have applied a similar contrivance in the case of ordinary weighing, and my object in the present note is to induce chemists and others experienced in such operations to give it a trial. Two magnets of steel wire, three or four inches long, are attached vertically to the scale pans, and underneath one of them is fixed a coil of insulated wire of perhaps 50 or 100 turns, and of four or five inches in diameter. The best place for the coil is immediately underneath the bottom of the balance case. It is then pretty near the lower pole of the magnet and is yet out of the way. The circuit is completed through a Leclanché cell and a common spring contact key, placed in any convenient position. The only precaution required is not to bring other magnets into the neighbourhood of the balance, or at any rate not to move them during a set of weighings. The other point as to which I wish to make a suggestion relates to the time of vibration of the beam. I think that with the view of obtaining a high degree of sensitiveness, the vibrations are often made too slow. Now, the limit of accuracy depends more upon the smallness of the force which can be relied upon to displace the beam in a definite manner than upon the displacement so produced. As in other instruments whose operation depends upon similar principles, *e.g.*, galvanometers, it is useless to endeavour to increase the sensitiveness by too near an approach to instability, because the effect of casual disturbances is augmented in the same proportion as that of the forces to be estimated. If the time of vibration be halved, the displacement due to a small excess of weight is, indeed, reduced in the ratio of four to one, but it is not necessarily rendered any more uncertain. The mere diminution in the amount of displacement may be compensated by lengthening the pointer, or by optical magnification of its motions. By the method of minor reading such magnification may be pushed to almost any extent, but I am dealing at present only with arrangements adapted for ordinary use.

In the balance (by Oertling) I am now using the scale divisions are finer than usual, and the motion of the pointer is magnified four or five times without the slightest inconvenience by a lens fixed in the proper position. The pointer being in the same plane as the scale divisions, there is no sensible parallax. In this way the advantage of quick vibrations is continued with easy visibility of the motion due to the smallest weights appreciable by the balance.

To illuminate the scale the image of a small and distant gas flame is thrown upon it by means of a large plane plain lens. This artificial illumination is found to be very convenient, as the instrument stands at some distance from a window, but it is not at all called for, in consequence of the use of a magnifying lens.

*Paper read before the British Association, Southport Meeting, Sept., 1883.

THE FIRE RISKS OF ELECTRIC LIGHTING.*

BY KILLINGWORTH HEDGES, C.E., M.S.T.E. AND E.

There is a great difference between the electric currents which have been in constant use for telegraphic purposes and those which are to be supplied by the undertakers under the Electric Lighting Act. The latter can only be said to be free from danger when the heat generated by the current is utilised in its right place, and not developed in the conductors or wires which lead the electricity to the incandescent lamps.

The Fire Risk Committee have already issued rules for guidance of users of electric light. These can hardly be said to embrace all the salient points of the new subject, which can only be arrived at after years of practical work. The necessity of proper regulations has already been recognised by the insurance offices, both in the United States and Germany, and some of their special rules are given in this paper.

The conductors must be properly proportioned for the current they have to carry; whatever resistance there is in the conductor will cause a corresponding development of heat, which will vary with the amount of electricity passing, and inversely as the sectional area.

The material must be free from impurity, otherwise an impure section will increase the resistance. The extraordinary difference in the conducting power of a sample of "commercial" Rio Tinto copper wire, as compared with the pure metal, was shown in an experiment by Dr. Matthiessen—the conducting power being only 13·6 as against 99·95 for pure copper.

The continued heating of an impure metallic conductor has a certain effect on its electrical resistance. With the sample just mentioned, the conducting power at 100° C. decreased from 13·58 to 13·558 after the wire had been heated for three days. It does not always follow that there will be a decrease in the conducting power, as with alloys the opposite effect is produced. A copper-silver alloy showed an increase of ·264

* Paper read before British Association, Southport Meeting, Sept., 1883.

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after having been heated to 100° C. for three days, and a tin-copper an increase of ·13.

As the temperature in Dr. Matthiessen's experiments was not increased ever 100° C., the author has made some further experiments—heating the wires by the electric current from a secondary battery to within a few degrees of their melting-point.

The following materials were tried—the wires and foils having such sectional area, and so arranged that, on the current being increased by twenty per cent., they were immediately fused.

The total length of each experiment was twenty-four hours, during which time the current passing through varied slightly, and the following is a mean of the results.

Material.	Resistance before Heating.	Resistance of Leads.	Difference after 24 hours.
	Ohms.	Ohms.	
No. 1. Commercial tin wire	·815	·8	— ·003
„ 2. Lead, soft	·835	·8	— ·005
„ 3. Copper, soft	·81	·8	No change
„ 4. Pure tinfoil	·86	·8	No change
„ 5. Tin and lead alloy...	·87	·8	— ·160
„ 6. Albo alloy, in foil...	·835	·8	No change
„ 7. Alumin. & tin alloy	·82	·8	+ ·0008

The resistances were in all cases taken at the temperature of the air, which averaged 69deg.

The sign — shows that the metal decreased in resistance, and + that it increased after continued heating. Nos. 1 and 3, tin and copper, were found to scale when heated.

A change has been noticed where high tension currents have been sent through a pure copper wire for some time—the wire in the armature of a Siemens machine which came under the notice of the author appeared to be brittle, and gave a fracture unlike pure copper.

The necessity of good electrical connections is very great, also special arrangements of switches and contact breakers, which, when left in unskilled hands, are liable to cause dangerous heating or an arc.

Short circuit is the danger which may be caused by badly arranged wires; most likely a conflagration will ensue without the remedy suggested by the Fire Risk Committee and the Board of Trade is adopted—of having a cut-out or fusible plug in the circuit which gives way when the current is in excess. These should be arranged to melt if the current is more than ten or fifteen per cent. of the working strength, otherwise absolute safety is not arrived at. Ordinary lead or tin wire cannot be used except for very small currents, as on fusing the metal is scattered in a globular form, when it is liable to cause fire. The plan adopted by the author is to take pieces of foil arranged like the leaves of a book; the thinness of the foil causes it to be almost volatilised when melted. The material found to be the most reliable is a special alloy of aluminium, termed albo metal, which is extremely tough, and can be worked much nearer to its fusing point than tin or lead.

The safety of an electric light installation is only insured by testing, which should be done by a current of higher electromotive force than it is intended to use.

When the work has been properly supervised no trouble should be experienced, and the electric light may be said to be much safer than gas, as it is free from those accidents which are due to a servant's carelessness, or by leakage of the pipes. Whatever danger there is with electric lighting is entirely localised to the generating station, where the dynamos and engines would be under constant supervision.

NUMBERS OF "THE ELECTRICIAN" OUT OF PRINT.—The following numbers of *The Electrician* are out of print, and cannot be supplied at the office, viz.:—Vol. 1, Nos. 3, 9, 19; Vol. 7, Nos. 8, 10, 12 to 18, 20, 21, 24 to 26; Vol. 8, 1, 3, 6 to 12, 15 to 26; Vol. 9, Nos. 2, 4, 24, 25; Vol. 10, No. 13.

THE TRANSMISSION OF POWER.*

M. DEPREZ'S EXPERIMENT AT GRENOBLE.

The machines employed were the same as at the workshops of the Northern Railway of France, but the wire on the magnets of the receiver was changed, and the insulation of the different parts had been improved; the two machines were also both insulated from the earth by means of foundations of dry wood.

The receiver was at Grenoble, whilst the generator was fitted up in the works of Damaye and Co., near the Vizille railway station, where it was driven by a turbine. The distance separating the two machines was 14 kilometres (8 miles 1,230yds.); they were connected by two silicium-bronze wires of 2mm diameter. The resistance of this line was 167 ohms. The resistances of the machines, taken at several intervals, were as follow:—

		Ohms.	
Generator	Magnets	20·10	R = 56·7 ohms.
	Rings ...2 × 18·30 =	36·60	
Receiver	Magnets	61·00	*r* = 97·00 „
	Rings	36·00	

The only apparatus for making mechanical measurements at the disposal of the commission were Prony brakes. In order, therefore, to measure the work absorbed by the generator they were compelled to resort to the method of substitution. The numerous verifications which were made during the course of the experiments fully justified the use of this method, which further offers the great advantage of being handier in practice than any other.

The turbine was connected by means of gearing to a spindle, this latter transmitting its motion to the generator by means of a countershaft which it was necessary to fit up in order to obtain the requisite speed. The brake was fitted on a pulley of about ·60m. diameter on the spindle. This brake had been carefully balanced; its lever arm was 2·50m. long. Its temperature was kept sensibly constant by the continuous flow of an emulsion of soapwater and olive oil. Assurance of the sensitiveness of the apparatus was also obtained by ascertaining that the brake being weighted with 54kgr. the addition of a weight of 50gr. (= 770 grains) was sufficient to destroy the equilibrium. The maximum work of the turbine when working under the best conditions as to speed, as measured by this apparatus, was found to be equal to 27 horse-power.†

If we call the weight on the brake P, the number of revolutions per minute N^0, the length of the lever arm L, then the work is given by the following expression:

$$T = \frac{2 \pi L N^0 P}{4{,}500} = \cdot 00349 \, N^0 P.$$

The work received at Grenoble was measured by a brake of very small dimensions, mounted on the pulley of the receiver. The lever arm being ·815, its formula was $T_u = \cdot 001138 \, n p$.

The method of proceeding to work was as follows:—The turbine was set going, but not the generator, that is, the loose pulley of the countershaft was alone caused to revolve. Equilibrium of the brake at Vizille was then obtained with a weight P, and N^0 was counted. Then a weight *p* was placed on the brake at Grenoble, and the generator thrown into gearing. The equilibrium was destroyed; it was re-established at Vizille, in such a way as to exactly obtain again the speed N^0 of the spindle of the brake, which was realised to within less than a revolution. The weight at Vizille then became P^1, and when the equilibrium was re-established, the indications of the two brakes were noted simultaneously.

Under these conditions it is evident that the work expended by the generator and the countershaft, or the gross motive power, is given by the expression

$$T\,b = \cdot 00349 \, (P - P').$$

This always supposes that the total work furnished by the turbine does not vary during the experiment. In order to be certain that this latter condition was fulfilled, after each series of experiments, that is to say, before modifying the speed of the turbine, the tare of the brake was taken afresh, the generator being idle,

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*A report communicated to the Paris Academy of Sciences by M. Boulanger, in the name of the commission nominated by the town of Grenoble, to report on M. Marcel Deprez's experiments. The commission was composed as follows:—President: M. Boulanger, Captain of Engineers. Secretary: M. Labatut, Demonstrator in Physics to the Faculty of Sciences. Members: MM. Jordan, Civil Engineer; Kuss, Mining Engineer; Merceron, Engineer of Roads and Bridges; Riviere, ditto; Pérémé, Engineer-Inspector of Telegraph Lines; Viallet, Civil Engineer; Charlon, ditto; Perrin, Director of the Professional School; Peyrard, Civil Engineer.

† The French horse-power is only 542½ ft.-lbs. per second, the English being 550 ft.-lbs. per second.

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TABLE I.

Date of the Experiments.	No. of the Experiments.	VIZILLE. No. of revs. per min. of spindle of brake. N^0	No. of revs. per min. of generator. Calculated N^1	Measured N	Weights on the brake. Generator at rest P	Generator working P^1	Total work on the spindle of the brake ·00349 N^0 P=T.	Motive power. Gross ·00349 N^0 ($P-P^1$) = Tb	Transmission deducted Tm	GRENOBLE. No. of revs. per min. of the receiver n.	Weights on the brake p.	Work received ·001138 n p=Tu.	Return $100 \times \frac{Tu}{Tm}$
					kg.	kg.	h.-p.	h.-p.	h.-p.		kg.	h.-p.	
1st September, 1883.	H 1	110	730	720	54·00	35·20	20·73	7·22	6·97	484	6	3·30	47·3
	H 2	110	730	730	54·00	32·00	20·73	8·45	8·20	446	7	3·55	43·2
	H 3	110	730	732	54·00	30·00	20·73	9·21	8·96	406	8	3·69	41·1
	K 1	130	870	865	40·50	21·50	18·37	8·62	8·33	614	6	4·19	50·3
	K 2	130	870	865	40·50	18·20	18·37	10·11	9·82	586	7	4·66	47·4
	K 3	130	870	875	40·50	15·50	18·37	11·34	11·05	553	8	5·08	45·9
	L 1	145	961	946	45·00	27·70	22·77	8·75	8·42	712	6	4·86	57·7
	L 2	145	961	954	45·00	24·20	22·77	10·43	10·10	686	7	5·46	54·0
	L 3	145	961	970	45·00	21·70	22·77	11·79	11·46	662	8	6·02	52·5
	M 1	160	1061	1040	35·00	17·00	19·54	10·05	9·69	830	6	5·66	58·3
	M 2	160	1061	1040	35·00	14·50	19·54	11·44	11·08	778	7	6·19	55·8
	M 3	160	1061	1050	35·00	12·10	19·54	12·69	12·33	734	8	6·68	54·1
	N 1	170	1127	1140	28·50	9·00	16·90	11·56	11·18	875	7	6·97	62·3

and it was ascertained each time that for the same weight the spindle of the brake acquired exactly the same speed.

Table I. gives the result of the experiments. The motive power T*m*, which was used to calculate the return, is equal to the gross motive power, deducting the loss due to friction at the countershaft. This loss, calculated by taking count of the weight of the countershaft and the tension of the belts, is equal to ·00227 N^0. There remains the slip of the belts to be taken into account, but comparison of the speed of the generator from time to time, calculated and measured, shows that the slipping is unimportant.

The figures contained in Table I* sufficiently speak for themselves, and it is useless to add anything as to their importance, the maximum return having reached 62 per cent. in the transmission of 7 horse-power.

Some remarks may be made on these figures, which show the perfect accord between the results obtained and theory, and which will serve to show the exactness of the measurements made, and the methods of making them. First of all, it may be remarked that at the speeds attained during the experiments the magnetic fields of the machines were near their points of saturation, and ceased to be functions of the current. The electrical measurements, including nearly fifty readings, showed moreover that the losses on the line might be neglected, and that the current might be considered as constant. If this be so, we should have, as M. Marcel Deprez has shown, by calling the current C

$$p = K\,C \text{ and } P - P' = K'C,$$

K and K′ being two constant co-efficients.

From this we get,

$$\frac{P - P'}{p} = \frac{K'}{K} = \text{const.}$$

Table II., drawn up from the data of the same experiments (1st September) shows that this relation is constantly verified.

TABLE II.

Nos. of the experiments.	Values of p.	Values of P.	Values of P′.	Values of P − P′.	Values of $\frac{P-P'}{p}$.
	kg.	kg.	kg.	kg.	kg.
H 1	6	54·00	35·20	18·8	3·13
H 2	7	54·00	32·00	22·0	3·14
H 3	8	54·00	30·00	24·0	3·00
K 1	6	40·50	21·50	19·0	3·16
K 2	7	40·50	18·20	21·3	3·04
K 3	8	40·50	15·50	25·0	3·12
L 1	6	45·00	27·70	17·3	2·88
L 2	7	45·00	24·20	20·8	2·97
L 3	8	45·00	21·70	23·3	2·91
M 1		35·00	17·00	18·0	3·00
M 2	7	35·00	14·50	20·5	2·92
M 3	8	35·00	12·10	22·9	2·86
N 1	7	28·50	9·00	19·5	2·78

REMARKS.—The mean of the values of $\frac{P - P'}{p}$ may be taken as equal to 3.

* The MSS. table sent in to the Academy by M. Boulanger comprised, besides the results of the experiments made on the 1st Sept., those of other preliminary experiments carried out on the 22nd and 23rd August.

From this we can deduce a useful mean for calculating the return. In point of fact, in Table I. the return has been calculated by means of the formula,

$$100 \times \frac{T\,u}{T\,m} = \frac{\cdot 001138 \times n\,p}{\cdot 00349\,N^0 (P - P')},$$

or, replacing the speed of the turbine shaft by that of the generator,

$$100\,\frac{T\,u}{T\,m} = \frac{\cdot 001138 \times 6\cdot 63 \times n\,p}{\cdot 00349 \times N\,(P - P')},$$

or lastly, by taking

$$\frac{p}{P - P'} = \frac{1}{3},$$

as given in Table II ,

$$100 \times \frac{T\,u}{T\,m} = \frac{n}{N} \times \cdot 72,$$

a relation in accordance with the data of Table I.

These remarks are important, for they show that the results foreseen by theory have been verified by the experiments at Grenoble, and they also show the degree of confidence that may be placed in the measurements taken by the commission.

A HISTORY OF ELECTRIC TELEGRAPHY TO THE YEAR 1837.

BY J. J. FAHIE, MEMB. SOC. TEL. ENGS. AND ELECS.*

(CONTINUED FROM PAGE 450.)

NOTE.—Being anxious to make his History as complete as possible, the Author will be grateful to his readers for any information, no matter how small, in relation to the subjects treated of in these pages.

CHAPTER IV.—DYNAMIC ELECTRICITY, HISTORY IN RELATION TO TELEGRAPHY.

The hooked torpedo, with instinctive force,
Calls all his magic from its secret source ;
Quick through the slender line and polished wand
It darts, and tingles in the offending hand.
—Pennant's "Oppian."

The discoveries of the Italian philosophers, Galvani and Volta, at the close of the last century, marked a new era in the history of telegraphy, by furnishing a form of electricity as tractable and copious, as that derived from friction was volatile and small.

Before entering further into this subject it may be well to say a few words on the early history of what has been called *Animal Electricity*—a force which is identical with, and whose early manifestations in certain fishes led up to, Galvanism.

Although this power is now known to exist in many fishes, and even in some of the lower animals,† the torpedo was the only instance known to the Ancients.

* The author reserves all rights of translation.

† With the aid of a microscope sparks have been seen to issue from the *annelides* and *infusoria*, and the luminosity of the glow-worm and other shining insects is thought to be due to the same cause. Margrave describes an insect, a native of Brazil, which, on being touched, gives a very perceptible shock ; and specimens of the *Sepia* and *Polypi* have also been observed to do the same. (Kirby and Spence's "Introduction to Entomology." London, 1826., vol. I., p. 110).

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Aristotle says :—"This fish hides itself in the sand, or mud, and catches those that swim over it by benumbing them, of which some persons have been eye-witnesses. The same fish has also the power of benumbing men." ("History of Animals," IX., 37.) Pliny writes :—"From a considerable distance even, and if only touched with the end of a spear, or staff, this fish has the property of benumbing the most vigorous arm, and of rivetting the feet of the runner, however swift he may be in the race." ("Natural History," XXXII., 2.) Plutarch declares that the torpedo affects fishermen through the drag net, and that, were water to be poured on a living one, the person pouring it would be affected, the sensation being communicated through the water to the hand. Claudian and Galen have much to the same effect, and Oppian is even more explicit, for he describes the organs by which the fish exerts its extraordinary power. "It is," he says, "attributable to two organs of a radiated texture, which are situated one on each side of the fish." (Lib. II., v. 62.)*

The ancients knew something also of what we would now call *Medical Electricity*. Thus we read that Dioscorides, the physician of Anthony and Cleopatra, used to cure inveterate headaches by applying a live torpedo to the head (Lib. II., Art. Torpedo); and that (as related by Scribonius Largus, chap. XLI.) Anthero, a freedman of Tiberius, was cured of the gout by the same means. The patient in such cases had to stand on the sea-shore with a live torpedo under foot, until not only the feet but the legs as far as the knees became numb.

The Gymnotus Electricus was first made known in Europe in 1671 by Richer, one of a party sent out by the French Academy for astronomical observations at Cayenne. The accounts which he brought home of its *shocking* powers were, however, received with much scepticism, and it was not until towards the middle of the last century that the observations of Condamine, Fermin, Bancroft, and others had fully established their credibility.

The gymnotus, which inhabits the warmer regions of Africa and South America, delivers far stronger shocks than the torpedo, the strokes of the larger ones being, according to Bancroft, instantly fatal. When one of average dimensions is touched with one hand a smart shock is felt in the hand and fore-arm ; and when both are applied it affects the whole frame, striking, apparently, to the very heart. Thus, Humboldt mentions that, treading upon an ordinary specimen, he experienced a more dreadful shock than he ever received from a Leyden jar, and that he felt severe pain in his knees and other parts of his body, which continued for several hours. According to Bryant, a discharge sometimes occasions such strong cramps of the muscles which grasp the fish that they cannot let it go.†

On the river old Calabar, the electrical properties of the gymnotus are used by the natives to cure their sick children ; a small specimen of the fish is put into a dish containing water, and the child is made to play with it, or the child is put into a tub of water and the fish put in beside it (*Edinburgh New Phil. Jour.*, No. 4.).

Of the remaining electrical fishes, the Silurus, introduced by Adanson, in 1751, is an inhabitant of the Nile and Senegal ; the Trichiurus inhabits the Indian Seas ; and the Tetraodon is found near the Canary Islands and along the American coast.

Although Redi, 1678, Kempfer, 1702, and others had made many and accurate observations on the torpedo, the electrical nature of the phenomena exhibited by this and the other fishes that we have named was not known, nor even suspected, up to the middle of the last century. The idea first occurred to Professor Musschenbröck of Leyden in reference to the torpedo, and nearly at the same time (1751), Adanson threw out a similar notion regarding the silurus ; but it was not till the year 1774 that the fact was clearly established by the experiments of Walsh, S'Gravesande, Bancroft, and others.‡

Walsh, in transmitting to Benjamin Franklin, then in London, the results of his researches for communication to the Royal Society, says :—"It is with peculiar interest that I make to you my first communication, that the effect of the torpedo appears to be absolutely electrical," and he adds, after going over the details, "He, who predicted and showed that electricity wings the formidable bolt of the atmosphere, will hear with attention that in the deep it speeds a humbler bolt, silent and invisible ; he, who analysed the electric phial, will hear with pleasure that its laws prevail in *animated* phials ; he, who by reason became an electrician, will hear with reverence of an instinctive electrician gifted at its birth with a wonderful apparatus, and with skill to use it." (*Phil. Trans.* 1774, p. 472.)

It is singular that, while the examination of the torpedo was going on in Europe, similar investigations were taking place in America with respect to the gymnotus. These were made in Philadelphia and Charleston by Drs. Williamson and Garden, and the same conclusions, grounded on the same *data*, were arrived at. These are thus summed up by their authors :—"As the fluid discharged by the eel affects the same parts that are affected by the electric fluid ; as it excites sensations perfectly similar ; as it kills and stuns animals in the same manner ; as it is conveyed by the same bodies which convey the electric fluid, and refuses to be conveyed by others that refuse to convey the electric fluid, it must itself be the electric fluid, and the shock given by the eel must be the electric shock." (*Phil. Trans.* 1775, p. 101.)

Though these early experiments thus led to the strong presumption that this peculiar animal power was precisely of the same nature with common electricity, yet they were very far from reaching all that absolute demonstration which alone satisfies the requirements of modern science ; and, hence, naturalists have ever been on the watch to improve every opportunity which could supply additional evidence. The subject of electricity, likewise, has since those days been prosecuted with the greatest success, and the phenomena of the respective subjects have mutually thrown light upon each other. As regards electricity, there are now a number of palpable effects which are considered as demonstrative of its presence and operation, chief amongst which are the electric spark, heat, magnetic virtue, and chemical agency. These positive proofs of the operation of electricity were soon desiderated in connection with the animals we have named, and one after another, by the ingenuity of experimenters, have been at last obtained.

Now to resume our subject. In the hundred years preceding the discoveries of Galvani and Volta, we find record of many observations of a character closely resembling the fundamental ones, which, in their hands, led to the grand discovery of dynamic electricity. Thus, in 1671, Richer noticed that the gymnotus was able to produce by its shocks a sort of sympathetic quivering in dead fishes lying around it. In 1678, Swammerdam, in some experiments before his friend and patron, the Grand Duke of Tuscany, produced convulsions in the muscle of a frog, by holding it against a brass ring from which it hung by a silver wire—an experiment which, as we will presently see, exactly resembles that by which Galvani became so famous more than a hundred years later. This celebrated experiment is thus described in Swammerdam's "Biblia Naturæ," vol. 2, page 839 :—

"Let there be a cylindrical glass tube, in the interior of which is placed a muscle, whence proceeds a nerve that has been enveloped in its course with a small silver wire, so as to give us the power of raising it without pressing it too much, or wounding it. This wire is made to pass through a ring bored in the extremity of a small copper support and soldered to a sort of piston, or partition ; but the little silver wire is so arranged that, on passing between the glass and the piston, the nerve may be drawn by the hand and so touch the copper. The muscle is immediately seen to contract."

Du Verney, in 1700, made a similar observation, and Caldani, in 1757, described what he called "the revival of frogs by electric discharges." Du Verney's experiment is thus described : —"M. du Verney showed a frog just dead, which, in taking the nerves of the belly that go to the thighs and legs, and irritating them a little with a scalpel, trembled and suffered a sort of convulsion. Afterwards he cut the nerves, and, holding them a little stretched with his hand, he made them tremble again by the same motion of the scalpel."*

Sulzer, in his "Nouvelle Théorie des Plaisirs," published at Berlin in 1767, described the peculiar taste occasioned by pieces of silver and lead in contact with each other and with the tongue. He, however, had no suspicion of the electrical nature of this effect, but thought it "not improbable that, by the combination of the two metals, a solution of either of them may have taken place, in consequence of which the dissolved particles penetrate into the tongue ; or we may conjecture that the combination of these metals occasions a trembling motion in their respective particles, which, exciting the nerves of the tongue, causes that peculiar sensation." (Note to text on page 155).

The next person to whom chance afforded an opportunity of making the discovery of galvanism, but who let it pass with as little profit as Sulzer and his predecessors had done, was Domenico Cotugno, professor of anatomy at Naples. His observations are contained in the following letter,† dated Naples, October 2, 1784, and addressed to the Chevalier Vivenzio :—

Sir The observation which I mentioned some days ago, when

* In the *Phil. Trans.* for 1773, the celebrated Hunter published the anatomical structure of the torpedo, showing the position of the electric organs. In a fish eighteen inches long it was found that the number of columns composing each organ amounted to 470.

† *Transactions of the American Society*, Vol. II. See also *Mechanics' Magazine*, for August 6, 1825.

‡ *Philosophical Transactions*, 1774 and 1775.

* Martyn and Chambers' "The Phil. Hist. and Mems. of the Royal Acad. of Sciences at Paris," London, 1742, Vol. I., p. 187. Du Verney was a celebrated anatomist, for whom the use of vaccine as early as 1705 is claimed with a great show of reason.

† Extracted from Cavallo's "Complete Treatise on Electricity," 4th Ed. London, 1795, Vol. 3, p. 6.

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we were discoursing together of the electrical animals, upon which I said that I believed the mouse to be one of the number, is the following :—

Towards the latter end of March I was sitting with a table before me; and observing something to move about my foot, which drew my attention, looking towards the floor, I saw a small domestic mouse, which, as its coat indicated, must have been very young. As the little animal could not move very quick, I easily laid hold of it by the skin of the back, and turned it upside down; then with a small knife that laid by me, I intended to dissect it. When I first made the incision into the epigastric region, the mouse was situated between the thumb and first finger of my left hand, and its tail was got between the two last fingers. I had hardly cut through part of the skin of that region, when the mouse vibrated its tail between the fingers, and was so violently agitated against the third finger, that, to my great astonishment, I felt a shock through my left arm as far as the neck, attended with an internal tremor, a painful sensation in the muscles of the arm, and with such giddiness of the head, that, being affrighted, I dropped the mouse.

(TO BE CONTINUED.)

BRITISH ASSOCIATION.

Address of the President of the Chemical Section.*

BY DR. J. H. GLADSTONE, F.R.S., V.P.C.S.

A sectional address usually consists either of a review of the work done in the particular science during the past year, or of an exposition of some branch of that science to which the speaker has given more especial attention. I propose to follow the latter of these practices, and shall ask the indulgence of my brother chemists while I endeavour to place before them some thoughts on the subject of Elements.

Though theoretical and practical chemistry are now intertwined, with manifest advantage to each, they appear to have been far apart in their origin. Practical chemistry arose from the arts of life, the knowledge empirically and laboriously acquired by the miner and metallurgist, the potter and the glassworker, the cook and the perfumer. Theoretical chemistry derived its origin from cosmogony. In the childhood of the human race the question was eagerly put, "By what process were all things made?" and some of the answers given started the doctrine of elements. The earliest documentary evidence of the idea is probably contained in the Shoo King, the most esteemed of the Chinese classics for its antiquity. It is an historical work, and comprises a document of still more venerable age, called "The Great Plan, with its Nine Divisions," which purports to have been given by Heaven to the Great Yu, to teach him his royal duty and "the proper virtues of the various relations." Of course there are wide differences of opinion as to its date, but we can scarcely be wrong in considering it as older than Solomon's writings. The First Division of the Great Plan relates to the Five Elements. "The first is named Water; the second, Fire; the third, Wood; the fourth, Metal; the fifth, Earth. The nature of water is to soak and descend; of fire, to blaze and ascend; of wood, to be crooked and to be straight; of metal, to obey and to change; while the virtue of the earth is seen in seed-sowing and ingathering. That which soaks and descends becomes salt; that which blazes and ascends becomes bitter; that which is crooked and straight becomes sour; that which obeys and changes becomes acrid; and from seed-sowing and ingathering comes sweetness."†

A similar idea of five elements was also common among the Indian races, and is stated by Professor Rodwell to have been in existence before the fifteenth century B.C., but though the number is the same, the elements themselves are not identical with those of the ancient Chinese classic; thus, in the Institutes of Menu, the "subtle ether" is spoken of as being the first created, from which, by transmutation, springs air, whence, by the operation of a change, rises light or fire; from this comes water, and from water is deposited earth. These five are curiously correlated with the five senses, and it is very evident that they are not looked upon as five independent material existences, but as derived from one another. This philosophy was accepted alike by Hindoos and Buddhists. It was largely extended over Asia, and found its way into Europe. It is best known to us in the writings of the Greeks. Among these people, however, the elements were reduced to four—fire, air, earth, and water—though Aristotle endeavoured to restore the "blue ether" to its position as the most subtle and divine of them all. It is true that the fifth element, or "quinta essentia," was frequently spoken of by the early chemists, though the idea attaching to it was somewhat changed, and the four elements continued to retain their place in popular apprehension, and still retain it even among many of the scholars who take degrees at our universities. The claim of wood to be considered an element seems never to have been recognised in the west, unless, indeed, we are to seek this origin for the choice of the word ὕλη to signify that chaotic material out of which, according to Plato and his school, all thing were created.‡ The idea also of a primal element, from which the others, and everything else, were originated, was common in Greece, the difficulty being to decide which of the four had the greatest claim to this honour. Thales, as is well known, in the sixth century B.C. affirmed that water was the first principle of things; but Anaxamenes afterwards looked upon air, Heraclytus upon fire, and Theracleides on earth, as the primal element. This notion of elements, however, was essentially distinct from our own. It was always associated with the idea of the genesis of matter rather than with its ultimate analysis, and the idea of *simple* as contrasted with *compound* bodies probably never entered into the thoughts of the contending philosophers.

The modern idea appears to have had a totally different origin, and we must again travel back to China. There, also in the sixth century B.C., the great philosopher Lao-tse was meditating on the mysteries of the world and the soul, and his disciples founded the religion of Taou. They were materialists; nevertheless they believed in a "finer essence," or spirit, that rises from matter, and may become a star; thus they held that the souls of the five elements, water, metal, fire, wood, and earth, arose and became the five planets. These speculations naturally led to a search after the sublimated essences of things, and the means by which this immortality might be secured. It seems that at the time of Tsin-she-hwang, the builder of the Great Wall, about two centuries before Christ, many romantic stories were current of immortal men inhabiting islands in the Pacific Ocean. It was supposed that in these magical islands was found the "herb of immortality" growing, and that it gave them exemption from the lot of common mortals. The emperor determined to go in search of these islands, but some untoward event always prevented him.*

Some two or three centuries after this a Taouist, named Weipahyang wrote a remarkable book called "The Uniting Bond." It contains a great deal about the changes of the heavenly bodies, and the mutual relation of heaven and men; and then the author proceeds to explain some transformations of silver and water. About elixir he tells us, "What is white when first obtained becomes red after manipulation on being formed into the elixir" ("tan," meaning red or elixir). "That substance, an inch in diameter, consists of the black and the white, that is, water and metal combined. It is older than heaven and earth. It is most honourable and excellent. Around it, like a wall, are the sides of the cauldron. It is closed up and sealed on every side, and carefully watched. The thoughts must be undisturbed, and the temper calm, and the hour of its perfection anxiously waited for. The false chemist passes through various operations in vain. He who is enlightened expels his evil passions, is delighted morning and night, forgets fame and wealth, comprehends the true objects of life, and gains supernatural powers. He cannot then be scorched by fire, nor drowned in water, &c., &c. . . . The cauldron is round like the full moon, and the stove beneath is shaped like the half moon. The lead ore is symbolised by the White Tiger; and it, like metal amongst the elements, belongs to the West. Mercury resembles the sun, and forms itself into sparkling globes; it is symbolised by the Blue Dragon belonging to the East, and it is assigned to the element wood. Gold is imperishable. Fire does not injure its lustre. Like the sun and moon, it is unaffected by time. Therefore the elixir is called 'the Golden Elixir.' Life can be lengthened by eating the herb called Hu ma; how much more by taking the elixir, which is the essence of gold, the most imperishable of all things! The influence of the elixir, when partaken of, will extend to the four limbs; the countenance will become joyful; white hair will be turned black; new teeth will grow in the place of old ones, and age at once becomes youth. . . . Lead ore and mercury are the bases of the process by which the elixir is prepared: they are the hinge upon which the principles of light and darkness revolve."

This description suggests the idea that the elixir of the Taouists was the red sulphide of mercury—vermilion—for the preparation of which the Chinese are still famous. That Weipahyang believed in his own philosophy is testified by a writer named Ko-hung, who, about a century afterwards, wrote the lives of celebrated Taouists. He tells how the philosopher, after preparing the elixir, took it, with his disciples, into a wood, and gave it first to his dog, then took it himself, and was followed by one of his pupils. They all three died, but, it appears, rose to life again, and to immortality. This brilliant example did not remain without imitators; indeed, two emperors of the Tang family are said to have died from partaking of the elixir. This circumstance diminished its popularity, and alchemy ceased to be practised in the Celestial Empire.

At the beginning of the seventh century the doctrine of Lao-tse was in great favour at the Chinese court; learning was encouraged, and there was much enterprise. At the same time the disciples of Mahomed carried their arms and his doctrines over a large portion of Asia, and even to the Flowery Land. Throughout the eighth century there were frequent embassies between eastern and western Asia, wars with the Caliphs, and even a matrimonial alliance. We need not wonder, therefore, that the teachings of the Taouist alchemists penetrated westward to the Arabian philosophers. It was at this period that Yeber-Abou-Moussah-Djafer al-Sofé, commonly called Geber, a Sabæan of great knowledge, started what to the west was a new philosophy about the transmutation of metals, the Philosopher's Stone, and the Elixir of Life; and this teaching was couched in highly poetic language, mixed with astrology and accompanied by religious directions and rites. He held that all metals were composed of mercury, sulphur, and arsenic, in various proportions, and that the the noblest metal could be procured only by a very lengthy purification. It was in the salts of gold and silver that he looked for the Universal Medicine. Geber himself was an experimental philospher, and the belief in transmutation led to the acquirement of a considerable amount of chemical knowledge amongst the alchemists of Arabia and Egypt. This gradually brought about a conviction that the three reputed elementary bodies, mercury, sulphur, and salt or acid, were not really the originators of all things. There was a transition period, during which the notion was itself suffering a transmutation. The idea became gradually clearer that all material bodies were made up of certain constituents, which could not be decomposed any further, and which, therefore, should be considered as elementary. The introduction of quantitative methods compelled the overthrown of mediæval chemistry, and led to the placing of the conception of simple and compound bodies upon the foundation of scientific fact. Lavoisier, perhaps, deserves the greatest credit in this matter, while the labours of the other

* Delivered at the Southport Meeting, September, 1883.

† Quoted from the translation by the Rev. Dr. Legge. In that most obscure classic the *Yi-King*, fire and water, wind and thunder, the ocean and the mountains, appear to be recognised as the elements.

‡ Students of the Apocrypha will remember the expression in the Book of Wisdom, xi. 17, "ἡ παντοδύναμός σου χεὶρ καὶ κτίσασα τὸν κόσμον ἐξ ἀμόρφου ὕλης" ("Thy Almighty hand, that made the world of matter without form"). The same book contains two allusions to the ordinary elements, vii. 17 and xix. 18 to 20. The word στοιχεῖον is used in the New Testament only in a general sense (2 Pet. iii. 10), or in its more popular meaning of the first steps in knowledge.

* Nearly all my information in regard to this Taouist alchemy is derived from the writings of the Rev. Joseph Edkins, of Pekin, and the matter is treated in greater detail in an article on the "Birth of Alchemy," in the *Argonaut*, vol. iii. p. 1.

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great chemists of the eighteenth and the beginning of the nineteenth centuries were in a great measure directed to the analysis of every conceivable material, whether solid, liquid, or gaseous. These have resulted in the table of so-called elements, now nearly seventy in number, to which fresh additions are constantly being made.

Of this ever-growing list of elements not one has been resolved into simpler bodies for three-quarters of a century; and we, who are removed by two or three generations from the great builders of our science, are tempted to look upon these bodies as though they were really simple forms of matter, not only unresolved, but unresolvable. The notation we employ favours this view and stamps it upon our minds.

Is it, however, a fact that these reputed elements are really simple bodies? or, indeed, are they widely different in the nature of their constitution from those bodies which we know to be chemical compounds? Thus, to take a particular instance, are fluorine, chlorine, bromine, and iodine essentially distinct in their nature from the compound halogens, cyanogen, sulphocyanogen, ferricyanogen, &c.? Are the metals lithium, sodium, and potassium essentially distinct from such alkaline bases as ammonium, ethylamine, di-ethylamine &c.? No philosophical chemist would probably venture to answer this question categorically with either "yes" or "no." Let us endeavour to approach it from three different points of attack—(1) the evidence of the spectroscope, (2) certain peculiarities of the atomic weights, and (3) specific refraction.

1. *The Spectroscope.*—It was at first hoped that the spectroscope might throw much light upon the nature of elements, and might reveal a common constituent in two or more of them; thus, for instance, it was conceivable that the spectrum lines of bromine or iodine vapour might consist of the rays given by chlorine *plus* some others. All expectations of this have hitherto been disappointed; what we do frequently find is a certain similarity of character among spectra of analogous elements, not rays of identically the same refrangibility. Yet, on the other hand, it must not be supposed that this negative result disproves the compound nature of elements, for as investigation proceeds it becomes more and more clear that the spectrum of a compound is not made up of the spectra of its component parts.

Again, the multiplicity of rays given out by some elements, when heated, in a gaseous condition, such as iron, has been supposed to indicate a more complex constitution than in the case of those metals, such as magnetism, which give a more simple spectrum. Yet it is perfectly conceivable that this may be due to a complexity of arrangement of atoms all of the same kind.

Again, we have changes of a spectrum at different temperatures; new rays appear, others disappear; or even there occurs the very remarkable change from a fluted spectrum to one of sharp lines at irregular intervals, or to certain recurring groups of lines. This, in all probability, does arise from some redistribution, but it may be a redistribution in a molecular grouping of atoms of the same kind, and not a dissociation or rearrangement of dissimilar atoms.

A stronger argument has been derived from the revelations of the spectroscope in regard to the luminous atmospheres of the sun. There we can watch the effect of heat enormously transcending that of our hottest furnaces, and of movements compared with which our hurricanes and whirlwinds are the gentlest of zephyrs. Mr. Lockyer, in studying the prismatic spectra of the luminous prominences or spots of the sun, has frequently observed that on certain days certain lines, say of the iron spectrum, are non-existent, and on other days certain other lines disappear, and that in almost endless variety; and he has also remarked that occasionally certain lines of the iron spectrum will be crooked or displaced, thus showing the vapour to be in very rapid motion, while others are straight, and therefore comparatively at rest. Now, as a gas cannot be both at rest and in motion at the same time and the same place, it seems very clear that the two sets of lines must originate in two distinct layers of atmosphere, one above the other, and Mr. Lockyer's conclusion is that the iron molecule was dissociated by heat, and that its different constituents, on account of their different volatility, or some other cause, had floated away from one another. This seems to me the easiest explanation of the phenomenon; and, as dissociation by heat is a very common occurrence, there is no *a priori* improbility about it. But we are not shut up to it, for the different layers of atmosphere are certainly at different temperatures, and most probably of different composition. If they are of different temperatures the variations of the spectrum may only be an extreme case of what must be acknowledged as true by every one more or less—that bodies emit, or cease to emit, different rays as their temperature increases, and notably when they pass from the liquid to the gaseous condition. And again, if the composition of the two layers of atmosphere be different, we have lately learnt how profoundly the admixture of a foreign substance will sometimes modify a luminous spectrum.

2. *Peculiarities of Atomic Weights.*—At the meeting of this association at Ipswich, in 1851, M. Dumas showed that in several cases analogous elements form groups of three, the middle one of which has an atomic weight intermediate between those of the first and third, and that many of its physical and chemical properties are intermediate also. During the discussion upon his paper, and subsequently,* attention was drawn to the fact that this is not confined to groups of three, but that there exist many series of analogous elements having atomic weights which differ by certain increments, and that these increments are in most cases multiples of 8. Thus we have lithium, 7; sodium, 23, *i.e.* 7 + 16; potassium, 39, *i.e.* 7 + (16 × 2); and the more recently discovered rubidium, 85, *i.e.* 7 + (16 × 5) nearly; and cæsium, 133, *i.e.* 7 + (16 × 8) nearly. This is closely analogous to what we find in organic chemistry, where there are series of analogous bodies playing the part of metals, such as hydrogen, methyl, ethyl, &c., differing by an increment which has the atomic weight 14, and which we know to be CH_2. Again, there are elements with atomic weights nearly the same or nearly multiples of one another, instances of which are to be found in the great platinum group and the great cerium group.† This suggests the analogy of isomeric and polymeric bodies. There is also this remarkable circumstance; the various members of such a group as either of those just mentioned are found together at certain spots on the surface of the globe, and scarcely anywhere else. The chemist may be reminded of how in the dry distillation of some organic body he has obtained a mixture of polymerised hydro-carbons, and may perhaps be excused if he speculates whether in the process of formation of the platinum or the cerium group, however and whenever it took place, the different elements had been made from one another and imperfectly polymerised.

But this is not the largest generalisation in regard to the peculiarities of these atomic weights. Newlands showed that, by arranging the numbers in their order, the octaves presented remarkable similarities, and, on the same principle, Mendelieff constructed his well-known table. I remind you that in this table the atomic weights are arranged in horizontal and vertical series, those in the vertical series differing from one another, as a rule, by the before-mentioned multiples of 8—namely 16, 16, 24, 24, 24, 24, 32, 32 – the elements being generally analogous in their atomicity and in other chemical characters. Attached to the elements are figures, representing various physical properties, and these in the horizontal series appear as periodic functions of the atomic weights. The table is incomplete, especially in its lower portions, but, with all its imperfections and irregularities, there can be no doubt that it expresses a great truth of nature. Now, if we were to interpolate the compound bodies which act like elements—methyl, 15; ammonium, 18; cyanogen, 26—into Mendelieff's table, they would be utterly out of place, and would upset the order both of chemical analogy and of the periodicity of the physical properties.

3. *Specific Refraction.*—The specific refraction has been determined for a large majority of the elements, and is a very fundamental property, which belongs to them apparently in all their combinations, so long at least as the atomicity* is unchanged. If the figures representing this property be inserted into Mendelieff's table, we find that in the vertical columns the figures almost invariably decrease as the atomic weights increase. If, however, we look along the horizontal columns, or better still if we plot the figures in the table by which Lothair Meyer has shown graphically that the molecular volume is a periodic function of the atomic weights, we shall see that they arrange themselves in a series of curves similar to but not at all coincident with his. The observations are not so complete or accurate as those of the molecular volumes, but they seem sufficient to establish the fact, while the points of the curves would appear to be, not the alkaline metals, as in Meyer's diagram, but hydrogen, phosphorus and sulphur, titanium and vanadium, selenium, antimony. Now, if we were to insert the specific refractions of cyanogen, ammonium, and methyl into this table, we should again show that it was an intrusion of strangers not in harmony with the family of elements.

But there is another argument to be derived from the action of light. The refraction equivalent of a compound body is the sum of the refraction equivalents of its compounds; and, if there is anything known for certain in the whole subject, it is that the refraction equivalent of an organic compound advances by the same quantity (7·6) for every increment of CH_2. If, therefore, the increment between the different members of a group of analogous elements, such as the alkaline metals, be of the same character, we may expect to find that there is a regular increase of the refraction equivalent for each addition of 16. But this is utterly at variance with fact; thus, in the instance above quoted, the refraction equivalent of lithium being 3·8, that of sodium is 4·8, of potassium 8·1, of rubidium 14·0, and of cæsium about 13·7. Neither does the law obtain in those series in which the increment is not a multiple of 8, as in the case of the halogens, where the increment of atomic weight is 45, and the refraction equivalents are chlorine 9·9, bromine 15·3, and iodine 24·5.

The refraction equivalents of isomeric bodies are generally identical; and the refraction equivalents of polymeric bodies are in proportion to their atomic weights. Among the groups of analogous elements of the same, or nearly the same, atomic weight we do find certain analogies; thus cobalt and nickel are respectively 10·8 and 10·4, while iron and manganese are respectively 12·0 and 12·2. But, as far as observation has gone at present, we have reason to conclude that, if metals stand to one another in the ratio of 2:1 in atomic weight, their refraction equivalents are much nearer together than that; while, on the other hand, the equivalent of sulphur, instead of being the double of that of oxygen, is at least five times as great.

The general tendency of these arguments is evidently to show that the elementary radicals are essentially different from the compound radicals, though their chemical functions are similar.

There remains still the hypothesis that there is a "primordial element," from which the others are derived by transmutation. With the sages of Asia it was the "blue ether," with Thales water, with Dr. Prout hydrogen. The earlier views have passed away, and the claims of hydrogen are being fought out by some of our ablest analists on the battlefield of atomic weights and their rigorous determination.

There does not appear to be any argument which is fatal to the idea that two or more of our supposed elements may differ from one another rather in form than in substance, or even that the whole seventy are only modifications of a prime element; but chemical analogies seem wanting. The closest analogy would be if we could prepare two allotropic conditions of some body, such as phosphorus or cyanogen, which should carry their allotropism into all their respective compounds, no compound of the one form being capable of change into a compound of the other. Our present knowledge of all allotropism and of variations in atomicity affords little, if any, promise of this.

The remarkable relations between the atomic weights of the elements and many peculiarities of their grouping force upon us the conviction that they are not separate bodies created without reference to one another, but that they have been originally fashioned or have been built up from one another according to some general plan. This plan we may hope gradually to understand better; but if we are ever to transform one of these supposed elements into another, or to split up one of them into two or three dissimilar forms of matter, it will probably be by the application of some method of analysis hitherto unknown.

Nothing can be of greater promise than the discovery of new methods of research; hence I need make no apology to others who have lately done excellent work in chemistry if I single out the Bakerian lecture of this year by Mr. Crookes on "Radiant Matter Spectroscopy." It relates to the

* *Phil. Mag.*, May, 1853.

† Another curious instance is the occurrence of nickel and cobalt in all meteoric irons, with occasionally chromium or manganese, the atomic weights and other properties of which are very similar.

* This exception includes not merely such changes as that from a ferrous to a ferric salt, but the different ways in which the carbon is combined in such bodies as ethene, benzene, and pyrene.

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prismatic analysis, not of the light transmitted or absorbed in the ordinary way by a solid or liquid, nor of that given out by incandescent gas, but the analysis of the fluorescence that manifests itself in certain bodies when they are exposed to an electric discharge in a highly-exhausted vacuum. He describes in an interesting and even amusing manner his three years' quest after the origin of a certain citron band which he observed in the spectrum of the fluorescence of many substances, till he was led into that wonderful labyrinth of uncertain elements which are found together in samarskite, and eventually he proved the appearance to be due to yttrium. As the test is an extremely delicate one, he obtained evidence of the very general dissemination of that element, in very minute quantities—and not always very minute, for the polypes that built up a certain pink coral were evidently able to separate the earth from the sea water, as their calcareous secretion contained about ½ per cent. of yttrium. We have reason to hope that this is only the first instalment of discoveries to be made by this new method of research.

I cannot conclude without a reference to the brightening prospects of technical chemistry in this country. I do not allude to the progress of any particular industry, but to the increased facilities for the education of those engaged in the chemical manufactures. First, as to the workpeople. Hitherto the young artisan has had little opportunity of learning at school what would be of the greatest service to him in his after career. The traditions of the Middle Ages were all in favour of literary culture for the upper classes, and the education suited for these has been retained in our schools for the sons of the people. It is true that some knowledge of common things has been given in the best schools, and the Education Department has lately encouraged the teaching of certain sciences in the upper standards. In the Mundella Code, however, which came into operation last year, "elementary science" may receive a grant in all the classes of a boys' or girls' school, and in the suggested scheme there is mentioned simple lessons on "the chemical and physical principles involved in one of the chief industries of England, among which agriculture may be reckoned," while "chemistry" is inserted among "the specific subjects of instruction" that may be given to the older children. It is impossible, as yet, to form an estimate of the extent to which managers and teachers have availed themselves of this permission, for the examinations of Her Majesty's inspectors under the new code have only just commenced; but one of the best of the board schools in London has just passed satisfactorily in chemistry both with boys and girls. I trust that in those parts of the country where chemical industries prevail chemistry may be largely taken up in our elementary schools.

The great deficiency in our present educational arrangements is the want of the means of teaching a lad who has just left the common school the principles of that industry by which he is to earn his livelihood. The more purely scientific chemistry, however, may be learnt by him now in those evening classes which may be formed under the Education Department, as well as in those that have long been established under the Science and Art Department. The large amount of attention that is now being given to the subject of technical education is creating in our manufacturing centres many technical classes and colleges for students of older growth.

As to inventors and the owners of our chemical factories, in addition to the Chemical Society and the Chemical Institute there has recently been founded the Society of Chemical Industry. It came into existence with much promise of success; at the close of its second year it numbered 1,400 members; it has now powerful sections in London, Manchester, Liverpool, Newcastle, and Birmingham; and it diffuses information on technical subjects in a well-conducted monthly journal.

May the abstract science and its useful applications ever prove helpful to one another, and become more and more one chemistry for the benefit of mankind.

BRUSH ELECTRIC LIGHT AND POWER COMPANY OF SCOTLAND.

Report of the directors for the period commencing with the allotment of the Company on the 3rd May, 1882, to 31st July, 1883, to be presented at the annual general meeting to be held at Dashwood House, New Broad-street, London, E.C., on Friday, the 28th September, 1883, at 2:30 p.m.:—

The directors herewith submit to the shareholders a statement of the accounts for the period between the allotment of the Company on the 3rd May, 1882, and the 31st day of July, 1883. The attention of the directors has unceasingly been given to pressing forward the general business of the Company, whether by concessions or sale of plant, or by endeavouring to secure provisional orders under the Board of Trade rules for lighting various towns in Scotland. Notwithstanding that the action of the Legislature imposed such serious conditions, and took away many rights the the directors thought they possessed when the Company was formed, every exertion has been made by your Board to sell machinery at a profit, or even to cover cost, but they have been comparatively unsuccessful, although the Company, at considerable expense, exhibited experimental lighting in every variety at Edinburgh, Aberdeen, and Dundee to demonstrate its usefulness and applicability. At Glasgow, our offer to erect trial lamps for the price of gas met with a refusal, and in our application for provisional orders, before the Board of Trade, for Glasgow, Edinburgh, Aberdeen, and Dundee, our overtures were met by such strenuous resistance from the local authorities, supported somewhat by the Board of Trade, that we were compelled to abandon the attempt, except in the case of Dundee, for which town a provisional order, reduced to fifteen years, has been issued in our favour, but which, in its final form, has been so beset by provisos that it is doubtful whether it could be profitably worked, at least until the demand for electric lighting becomes more general than seems probable at present. The people of Scotland, as represented by their town authorities, are, at present adverse to the introduction of the electric light, or only wish it for trial on terms that will not pay this Company, while the competition of 24 candle-power gas in Scotland is also serious, especially where the inhabitants require heat as well as light in their rooms, and treat with indifference all arguments as to vitiated air, destruction to silver plate, pictures and ornaments, and finally there is the difficulty and expense of working a concern like this with practically no support from Scotland. The directors trust the shareholders will give them credit for protecting the capital and utilising it at good interest to the best of their ability. Owing to representations made to them, the board were desirous of equalising the two different classes of shareholders, and were advised as to the proposals laid before the last meeting, but afterwards finding that legal doubts existed and that expensive litigation would probably ensue, they desisted, and for the reasons given above, now recommend the voluntary winding-up of the Company upon an equitable basis. Anticipating that the shareholders will agree to a voluntary liquidation, and on this point the Board are led to believe that there is a very strong feeling, they have called an extraordinary meeting to follow on the ordinary meeting at which a special resolution to the above effect will be proposed. The statement of accounts accompanying this shows the position of the Company, and the probable sum to be divided, less winding-up charges and some unimportant liabilities, but as there are but few creditors the liquidation should not occupy much time. There are also assets other than cash in regard to which the directors have made a conditional arrangement for the disposal of the most important portion, which will considerably improve the division, and they can further state that the great majority of the fully-paid shareholders have signified their assent to an equitable arrangement in the voluntary winding up.

COMPANIES' SHARE LIST.

TELEGRAPHS.

Companies.	Closing Prices Sept. 28.	Business Done Week Ending Sept. 26. Highest.	Lowest.
Anglo American	47¼, 47¾	47½	47¼
Do. Preferred	79¼, 79¾	80	79¾
Do. Deferred	17, 17½	17⅜	17
Brazil Submarine	10⅞, 11	11⅛	11 1-
Cuba	10½, 11	—	—
Do. Preference	17, 18	—	—
Direct Spanish	5¼, 5½	—	—
Do. Preference	15⅝, 16½	16	—
Direct United States Cable	12 9-16, 12 11-16	12¾	12⅝
Eastern Telegraph	10 11-16, 10 13-16	10⅞	10⅝
Do. 6 per Cent. Preference	12¾, 13¼	13⅛	12 15-16
Do. 5 per Cent. Debentures, 1899	103, 107	—	—
Eastern Extension	11¼, 11¾	11 7-16	11¼
German Union	9¾, 10½	10⅛	—
Globe Telegraph and Trust Company	7 9-16, 7 11-16	7⅝	7½
Do. Preference	12¾, 13	13⅛	13 3-13
Great Northern	12¾, 13	13⅛	12¾
Indo-European	31, 32	—	—
Mediterranean Extension	1½, 2	1¾	—
Do. Preference	2, 4	—	—
Reuter's	8¾, 9¼	—	—
Submarine	220, 230	224	223
West India and Panama	⅞, ⅞	—	—
Do. 1st Preference	6½, 6⅞	6½	—
Western Brazilian	5¾, 6	6	5⅞
West. Union 7 per Cent. 1st Mortgage	122, 124	—	—
Do. 6 per Cent. Sterling Bonds	100, 103	—	—

TELEPHONES.

Companies.	Closing Prices Sept. 28.	Highest.	Lowest.
Consol. Telephone and Maintenance	5-16, 7-16	5-16	—
Oriental	5-16, 7-16	—	—
United Telephone	8⅝, 8⅞	8½	8⅞

ELECTRIC LIGHT.

Companies.	Closing Prices Sept. 28.	Highest.	Lowest.
Anglo-American Brush Lgt. (£7 paid)	2½, 2¾	2 11-16	2¾
Do. (fully paid)	5, 5½	—	—
Hammond Light (£3 15s. paid)	2½, 2¾	2 15-16	—
Eastern Electric (£4 paid)	1, 1¼	—	—
Swan	1⅞, 2⅛	2⅛	2
Maxim-Weston	⅛, ⅛	—	—

MISCELLANEOUS.

Companies.	Closing Prices Sept. 28.	Highest.	Lowest.
Telegraph Construction	33, 33½	33½	33½
India Rubber, Gutta Percha, and Telegraph Works	29½, 30½	—	—

TRAFFIC RECEIPTS FOR AUGUST, 1883.

Companies.	Aug., 1883.	Aug., 1882.	Incrse.	Decrs.
Anglo-American Telegraph Company	—	—	—	—
Brazilian Submarine Company	—	—	—	—
Cuba Submarine Company	2,275	2,595	—	320
Direct Spanish Telegraph Company	1,514	1,790	—	276
Direct United States Cable Company	—	—	—	—
Eastern Telegraph Company	—	—	—	—
Eastern Extension Telegraph Company	38,126	32,025	6,101	—
Great Northern Telegraph Company	22,960	—	—	—
Submarine Telegraph Company	—	—	—	—
West Coast of America Telegraph Company	—	—	—	—
Western and Brazilian Telegraph Company	—	—	—	—

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NOTES.

Electric Lighting for Cartridge Factories.—The cartridge factory at St. Petersburg is electrically lighted.

Telegraphic Communication Restored.—Telegraphic communication with Brownsville (Texas) is now restored.

The Edison System in Germany.—It is reported that a large central station on the Edison system is to be established at Leipzig.

The Jablochkoff System.—This system is in use in the Antwerp Docks, and the company is under a contract to supply it for ten years.

Globe Telegraph and Trust Company.—The directors of this company announce the proposed payment of a dividend of 2s. per share on the original shares.

Alteration of Address.—The offices of the Great Western Electric Light and Power Company have been removed to No. 4, Great Winchester-street-buildings, E.C.

Earthquakes.—Reuter's telegrams state that two shocks of earthquake were felt at Agram on the night of Sept. 27, whilst another shock was experienced at Athens at 10:20 a.m. on Oct. 1.

Electric Lighting in Mills.—The Trachenau Mill at Kieritzseh, in Saxony, is lighted by Swan incandescent lamps to the number of thirty-four. The current is supplied by a Fein dynamo.

The Electro-Amalgamator Company.—It has been agreed to wind up this company, in order that a new company of the same name, and presumably the same objects, may be registered.

Direct Spanish Telegraph Company.—The estimated traffic receipts of this company for the month of September, 1883, were £1,701, against £1,812 in the corresponding period of last year.

West India and Panama Telegraph Company.—The estimated traffic receipts of this company for the half month ended the 30th September are £2,217, as compared with £1,779 in the corresponding period of 1882.

The Vienna Exhibition.—By direction of the War Department, Captain Addison, secretary to the Royal Engineer Committee, has proceeded to the Vienna Exhibition for the purpose of inspecting the various electrical appliances there shown and reporting on their adaptability to military requirements.

The Telephone in Buenos Ayres.—From advices received by the directors of the River Plate Telephone Company it appears that the telephone system continues to find favour in that city and Monte Video. There was an increase of ninety-four subscribers, taking 104 telephones, during the month of August.

Books Received.—"Electricity as a Motive Power," by M. le. Comte du Moncel, translated from the French by C. J. Wharton. Published by Messrs. Spon, of Charing-cross, S.W.—"A Practical Treatise on Lightning Protection," by H. W. Sang, new and revised edition, published by D. Van Nostrand, New York.

Cuba Submarine Telegraph Company.—The number of messages passing over the lines of this company during the month of September was 2,651, estimated to produce £2,500, against 2,473 messages, producing £2,283 in the corresponding month of last year. The traffic receipts for the month of June, estimated at £2,700, realised £2,688.

Works' Lighting.—The contract for the lighting of Messrs. T. Boyd and Co.'s large print works at Levenshulme, Manchester, has been secured by Mr. F. D'A. Goold, electrical engineer, 79 and 80, Hawarth's-buildings, Manchester. The lighting will include 150 Swan 20 candle-power lamps, the current being obtained from a Ferranti dynamo.

New Telegraph Station in China.—It is notified by the Great Northern Telegraph Company that a telegraph station has been opened at Tungchow, twelve English miles distant from Pekin, which latter city is reached by means of a regular courier service. The rate from England to Tungchow is 10s. per word, and for the transmission by courier from that place to Pekin an extra charge of 1s. 10d. per message is made.

Electric Lighting for Railway Stations.—Experiments have recently been carried out at the Chemnitz Railway Station, in Saxony, with Pilsen and Siemens lamps. The current was supplied by Schuckert and Siemens dynamos respectively. The Siemens lamp is stated to have given the best results as far as candle-power is concerned. Each lamp required about one h.-p.

Electric Lighting on Ships.—The "Orontes" troopship sailed from Portsmouth on Monday last. She has been fitted with incandescent lamps by the Swan United Electric Light Company. The order for lighting the ship was received in June last, and in spite of some trouble occasioned by the new pattern of engines employed, the lights were all running satisfactorily when she sailed.

Determining the Magnetic Meridian.—M. E. Bisson has constructed a compass by means of which the magnetic meridian can be determined on board iron ships. The theory upon which he constructed this compass is given in the *Comptes Rendus* for September 24. A compass constructed by M. Bisson has been submitted to the hydrographic committee of the French Admiralty, and is to be tested on board one of the ironclads of the French navy.

The Brighton Electric Railway.—The Works Committee of the Brighton Town Council have agreed to the extension of the electric railway on the shore as far as the Paston-place Groyne, and to the erection of an electric lift from the beach to the Marine Parade. This railway, so far as it has at present been constructed, was described in *The Electrician* for Sept. 1, p. 369. Our readers will remember that its initiation was due to the energy of Mr. Magnus Volk, electrical engineer to the Brighton Corporation.

Eastern Extension Telegraph Company.—The traffic receipts of this company for the month of September, 1883, amounted to £37,271 and to £32,955 for the corresponding period of 1882, being an increase of £4,316. The company notify that the accounts for the half year ended June 30 last show, subject to audit, a net profit of £107,356. After providing for two quarterly interim dividends and a bonus of 1s. per share, making together 3 per cent. for the half year, there remains a balance of £32,356 to be carried forward.

Soiree at Guy's Hospital.—At a *soirée* given by the officials of Guy's Hospital, London, on Monday evening to mark the opening of the winter term, the corridors and rooms were lighted by means of over 100 incandescent lamps of twenty candle-power. The current for these was supplied from Sellon-Volckmar accumulators, which were brought to the hospital in two vans and the wires connected to them without the necessity of unloading. The entire work in con-

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nection with this installation was done in about two days and a half by the Hammond Electric Light and Power Company.

A HURRICANE.—A correspondent of *The Times*, writing from Roseau, Dominica, under date Sept. 10, in a graphic account of the hurricane which swept over that island on the 4th and 5th Sept., says:—"During the continuance of the hurricane blinding rain prevailed, and vivid flashes of lightning in rapid succession denoted the nearness of the thunder, which was, however, quite inaudible in consequence of the terrific fury of the wind, which roared like one sustained discharge of artillery. The same experience was recorded in respect of the great hurricane of Barbados on Aug. 11, 1831."

RONALDS' TELEGRAPH.—Mr. A. J. Frost, librarian to the Society of Telegraph Engineers, has kindly forwarded us a facsimile copy of the letter, dated August 5, 1816, sent by Sir John Barrow, secretary of the Admiralty, to Sir Francis Ronalds, F.R.S., in which he states, in answer to Sir Francis Ronalds' request that his telegraph might be inspected, "Telegraphs of any kind are now wholly unnecessary." There are, we believe, but twelve facsimile copies of this curious letter extant. Our readers will find it referred to by Mr. J. J. Fahie in his "History of Electric Telegraphy," in our issue of the 8th September, p. 405.

PRESTON (LANCS.) TELEPHONIC EXCHANGE.—At a meeting of the Lulwood Local Board, near Preston, on the 28th ultimo, the tender of Mr. Sharples, of 7, Fishergate, Preston, for connecting the board offices and their waterworks at Haighton with the Preston Telephonic Exchange was accepted. The distance to the waterworks is about four miles. At the board offices and Haighton water level indicators will be fixed so that the wire can be of use for either telephonic purposes or water-level indicating. The offices of the engineer and chairman of the board are also connected with the exchange. The instruments used are Crossley transmitters and Bell telephones.

GREAT NORTHERN TELEGRAPH COMPANY.—The laying of this company's new cables from Nagasaki to Shanghai has been effected, and the Company's northern section, between Wladiwostock—Japan—Shanghai, is thus duplicated and now open for traffic. As the southern section, from Shanghai to Hongkong, has also been duplicated by means of a cable laid by the Eastern Extension Telegraph Company, under agreement with this company (a cable which also gives Foochow direct telegraph connection), the whole line from London to Japan, China and Hongkong is now duplicated, in some places even triplicated, and the efficiency in the working of this line will thus in future be materially increased.

FIRE ALARMS IN NOTTINGHAM.—The local press in Nottingham are unanimous in praising the fire alarms introduced into that town by the National Telephone Company, in March last. One paper says:—"A large majority of the fires which have occurred since they were erected have been signalled by these alarms, thereby saving a vast amount of property, if not of life, which but for this speedy and effective means of communication must have been destroyed. In nearly every instance the brigade has left for the scene of the fire within a minute of the alarm going off. The whole of the firemen's houses are in electric communication with the central fire station, and by this means the men can be summoned in the space of a few seconds."

A NEW INTERRUPTER.—Herr E. Budde some time since devised a new form of mercury interrupter. It is known that when an ordinary mercury interrupter works in air the surface of the mercury becomes oxidised, owing to the sparking which takes place. To avoid this, Herr Budde surrounded the mercury with an atmosphere of hydrogen. He used an interrupter like that of Foucault, and covered it with a glass case. Into this case he directed a current of pure and dry hydrogen. The gas was caused to pass first over concentrated sulphuric acid and then over lime. When the atmosphere in the case had been replaced by hydrogen, the interrupter was set in motion, and the stream of hydrogen was almost entirely stopped. Under these conditions Herr Budde stated that mercury would remain bright after four hours' work.

CHESS BY TELEPHONE.—On Saturday last a game of chess was played between Wolverhampton and Birmingham by means of the telephone. The Wolverhampton players were seated in the National Telephone Company's office in that town, while the Birmingham players were at the Curzon Hall. The game was played with living pieces. The result of this game was a draw. It was intended to play games selected from the works of English and foreign players during the past week, and to publish the results on a board in Curzon Hall, where a bazaar is being held. The telephonic arrangements were carried out under the superintendence of Mr. R. Ryder, district secretary, of the National Telephone Company at Birmingham. Games with living pieces have become somewhat common of late, but we believe that this is the first occasion upon which their movements have been directed by telephone.

ELECTRIC LIGHT ON BOARD SHIPS.—A correspondent calls our attention to the completeness of the lighting on board other vessels than the "Oregon." The following vessels are mentioned:—The "Arizona," with 295 Swan lamps and duplicate machines and engines; the "Normandie" with 400 Swan lamps and duplicate machines and engines. She has also 16 arc lamps, with a separate machine and engine, every lamp on board, including the masthead and side lights, are electric, and in addition to these she has a set of accumulators for use in dry dock, or at other times when steam may not be available; the "Aurania" with 550 Swan lamps, 2 arc lamps for working cargo, duplicate machines and engines for the passenger department, and duplicate machines and engines for the engine and boiler department. Both the "Normandie" and the "Aurania" have a lamp in each state room under control of the passenger.

VOLCANIC ERUPTIONS AND THE TELEPHONE.—The agent of the Oriental Telephone Company, at Singapore, Mr. A. C. M. Weaver, writes as follows, under date 30th August:—"No doubt news has reached London of the violent eruption of Mount Kaakatow, in Sunda Straits, and I thought it might be interesting to inform you of the effect on telephones in Singapore, though nearly 500 miles distant. Till three p.m. on Monday, 27th, conversation was utterly impossible on the Ishore line. On raising the tubes a perfect roar as of a waterfall was heard, and by shouting at the top of one's voice the clerk at the other end heard the voice, but of the whole not one single sentence was understood. The same noise, but to a less extent, was noticed on every line here, and sometimes while listening to the Ishore line instruments, a report like a pistol was heard." The telephone line crosses the strait between Singapore and Ishore by a short bit of cable about one mile in length.

CONVERSAZIONE.—At the close of the meeting of the Iron and Steel Institute at Middlesbrough last week, a grand reception and *conversazione* was given at Marton Hall, by Mr. Bolckow, where, we understand (through the courtesy of Mr. Robert Hammond), the splendid conservatories were lighted throughout with Swan lamps specially for the

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occasion. The reception was held on the Friday evening (21st ult.), and on Wednesday afternoon, Mr. Hammond, who was in Middlesbrough, telegraphed to the company's works to charge 25 Sellon-Volckmar secondary batteries. These were charged during the Wednesday night and were sent down by passenger train to Middlesbrough on Thursday. The batteries were fixed in an adjoining building and the whole of the wires and lamps fixed in the conservatories during the Friday, the whole of the lights being switched on at seven o'clock, and running without a hitch till one a.m. the following morning. This was quick work and well carried out.

Lighting Railway Carriages.—If anything of a really satisfactory character is to be done in lighting railway carriages by electricity, electricians are losing ground and opportunity. Some time since the railway companies were inclined to entertain proposals for electric lighting, but nothing of a really working character could be brought forward. It is questionable after the results of some of the trials whether the companies will now be so ready to look with favour on electricity in railway coaches. We learn that the Midland Railway Company, after a careful trial, has decided to adopt the Pintsch system of compressed oil gas illumination, and the Pintsch's Patent Lighting Company has received orders to provide the necessary works and fittings for immediate mounting in a large number of coaches. We say this has been decided upon after a careful trial, this should rather be after long consideration, for the system has been in unbroken successful operation for several years in thousands of coaches on the continent, and several hundreds in this country, and it is much cheaper than oil.

The Birmingham and Midland Institute.—Sir William Thomson delivered his inaugural address, as president of this institute, on Wednesday evening, taking for his subject, "Means by which the human mind acquires knowledge of external matters." He said the common enumeration of the gateways of knowledge was five—taste, smell, hearing, sight, and touch, and the Irishman made a sixth sense—common sense. One hundred years ago Dr. Thomas Browne, professor of philosophy in Glasgow University, propounded this theory, making the division of roughness and resistance. The senses he wished to explain were heat and force, the subdivision of touch, in addition to sight, hearing, taste, and smell. He did not in that favour the superstition of magnetism or mesmerism, of which they heard so much. Clairvoyance and so on were the result of observations somewhat mixed up with wilful imposture, acting on trusting minds; but if there were not a magnetic sense he wondered greatly. He thought it possible that there might be a magnetic sense, and perhaps an electric sense.

A Medical Battery.—*La Lumière Electrique* describes a small medical battery, the design of M. Soares, of Lisbonne, as follows:—It is composed of a small cylindrical ivory box, in which are piled, one on the other, fifteen small round plates of copper, paper, and zinc, forming five small voltaic couples. By means of a compass key, two small discs of silvered copper are screwed on to the box. The disc, which is in connection with the last zinc plate, is marked. The sides of the box are pierced with small holes. To make the battery work it is only necessary to plunge it into strong salt water for a little while, then wipe it, and it is ready. It is used, says our contemporary, to cure neuralgic pains in the gums. The method of using it is to place it so that the zinc pole touches the gum and the positive pole the inside of the lip. It is not advisable to use it for more than five minutes, as, despite its small size, the current is pretty strong. If, adds our contemporary, somewhat facetiously we think, the pain is not gone after five minutes' use, it is more than probable that the remedy is useless.

Telephonic and Telegraphic Facilities.—At the meeting of the Associated Chambers of Commerce, held at Derby during this week, the following resolutions were passed:—Mr. Watson (Hawick) proposed, "That a deputation be appointed to represent to Her Majesty's Postmaster-General (1) the necessity of cheapening and facilitating foreign and colonial telegraphic communication; (2) that the principal lines of wires in large towns should be conveyed underground." Mr. Seaton (Hull) moved, "That it is desirable the present excessive rates charged for telephonic communication by the Post Office Exchange, or for private wires supplied by them, should be reduced, and that the Associated Chambers again bring the question before the Postmaster-General; (2) that the Postmaster-General be respectfully requested to grant licenses on such terms and royalties, to responsible persons and companies, for the establishment of telephonic exchanges and trunk lines to enable them to carry on such exchanges at the smallest cost to the public." The second paragraph was added on the suggestion of Mr. Reid (Sunderland).

The Portrush Electric Railway.—This railway was opened by the Lord-Lieutenant of Ireland on Friday last, Sept. 28. It was intended to have been opened some weeks since, but one cause and another produced the delay that has occurred. The railway is 6½ miles long, and has a gauge of 3ft. Its construction has cost £45,000. It connects the well-known Giant's Causeway with the little seaside town of Portrush, a watering place in the north of Ireland which has been dubbed by some "the Brighton of Ireland." The correct title of the new line is the Giant's Causeway, Portrush, and Bush Valley Electric Railway. A portion of the line was completed in May last as far as Dunluce, and the trials made on it were so satisfactory that it was resolved to extend it to Bushmills, within easy distance of the Giant's Causeway. At first the Siemens dynamo supplying the current to the motor on the locomotive car was driven by a steam engine stationed at Portrush. As the line runs close to some falls on the River Bush, it was determined to utilise the water-power in place of steam. Turbines were therefore erected at the falls, and now drive the dynamo which supplies the requisite current to the line. The engine and dynamo at Portrush are still kept in reserve in case of a breakdown. The whole of the undertaking has been carried out by Mr. W. A. Traill, assisted by Mr. E. B. Price, under the direction of Sir William Siemens. A detailed account of the construction of the line was given in our issue for April 21, of this year. (*The Electrician*, Vol. X., p. 545.) We had hoped to have given some details of the method of utilising the water-power by means of turbines in our present issue, but the pressure on our space precludes this, at all events for this week.

International Electrical Exhibition in Philadelphia.—An exhibition of this character is to be held in Philadelphia, U.S.A., commencing on Tuesday, September 2nd, 1884, under the auspices of the Franklin Institute of the State of Pennsylvania for the Promotion of the Mechanic Arts. From the eminent reputation of this institution, coupled with the fact that the projected exhibition will be the first in America exclusively devoted to this important and progressing branch of science, the above announcement has attracted unusual interest throughout the United States, and the exhibition will undoubtedly afford an admirable opportunity of witnessing a representative display of American dis-

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covery and invention in electricity. To increase its scientific and industrial importance, as well as to add to its attractiveness it was determined shortly after its inception to give it an international character. The importance of the project having been properly represented to the Congress of the United States, an Act was passed which, having received the signature of the President of the United States, is now the law. This official recognition provides for the admission into the United States, duty free, of all articles for exhibition only. The text of this Act of Congress is as follows:— "Whereas the Franklin Institute of the State of Pennsylvania for the Promotion of the Mechanic Arts proposes to hold an exhibition of electrical apparatus, machinery, tools, and implements, and other articles used in scientific and mechanical and manufacturing business and investigations; and whereas it is deemed desirable to promote the success of such an exhibition by all reasonable encouragement, in order that it may be made useful for the promotion of knowlege; therefore, be it resolved by the Senate and House of Representatives of the United States of America, in Congress assembled, that all articles that shall be imported for the sole purpose of exhibition at the Exhibition to be held by the Franklin Institute of the State of Pennsylvania for the Promotion of the Mechanic Arts in the city of Philadelphia, in the years 1883 or 1884, shall be admitted without payment of duty or customs fees or charges under such regulations as the Secretary of the Treasury shall prescribe; provided that all such articles as shall be sold in the United States, or withdrawn for consumption therein at any time after such importation, shall be subject to the duties, if any, imposed on like articles by the revenue laws in force at the date of importation; and provided further that in case any article imported under the provisions of this joint resolution shall be withdrawn for consumption, or shall be sold without payment of duty as required by law, all the penalties prescribed by the revenue laws shall be applied and enforced against such articles, and against the persons who may be guilty of such withdrawals or sales." Every effort, we believe, will be made by the Franklin Institute to secure a large and important representation of the progress of foreign countries, and that the most liberal provisions will be made to place European and American exhibitors on a fair and equal footing. All information required by exhibitors, including the classification of exhibits, regulations for the entry of articles for competition, advices as to the best modes of transportation, custom house regulations, and all other needful information, will be furnished to persons making application for space for exhibits. Such applications should be made to the secretary, Franklin Institute, Philadelphia, U.S.A.

On the Working of a Turbine.—The following note has been sent by M. Marcel Deprez to the Paris Academy of Sciences, and is of interest in connection with the report on his Grenoble experiments, published in our last issue. He says:—"When the experiments of the Grenoble Municipal Committee were ended it seemed to me to be of interest to study the working of the turbine which drove the generator at Vizille station. This turbine drove several sets of gearing, which ordinarily set in motion the cement mills, but at the time of the experiments these mills were not working, so that the gearing worked without any load. The last countershaft driven by the turbine carried a Prony brake fitted up under the supervision of the committee, and a large pulley connected by a belt to the pulley of the generator. I caused this belt to be taken off, and causing the sluice gate of the turbine to be raised to about ¼in. of its maximum height, I had weights placed on the brake-plate, increasing by arithmetical progression, and carefully measured the speed of the brake-spindle at each increase of weight. I then altered the height of the sluice gate and repeated the experiment. The following figures show the results obtained for increasing heights of the sluice gate. Each experiment lasted ten minutes, during which time the speed remained absolutely constant:—

Experiment.	Weight on the brake.	No. of revolutions of the brake per minute. Measured.	Calculated.	Total work of the turbine in h.-p.
A	20	147·5	147·5	10·30
	25	139·5	139·7	12·17
	30	132·5	131·8	13·87
	35	—	124·0	—
	40	117	116·2	16·33
	45	—	108·3	—
	50	100·5	100·5	17·54
B	20	162	162	11·31
	25	153	154·5	13·35
	30	146	147	15·28
	35	138	139·5	16·85
	40	131	132	18·29
	45	124·5	125·5	19·54
	50	116	117	20·24
	55	110	109·5	21·11
	60	102	102	21·36
C	40	144	144	20·10
	50	130	130	22·68
	60	116	116	24·29
D	40	148	148	20·66
	50	136	136	23·73
	60	124	124	25·96

An examination of the column of speeds given with the various weights shows that when the weights on the brake increase in arithmetical progression the speeds of the turbine also decrease in exact arithmetical progression. This law was verified within very wide limits, for the weights varied between 20kg. and 60kg. It follows from this that the law connecting the weight on the brake and its speed is very exactly represented by an equation of the first degree, as follows:— $\frac{F}{F_0} \times \frac{V}{V_0} = 1$, in which F and V represent the weight and speed of the brake in every experiment, F_0 the weight on the brake which is the equivalent of the effort required to completely stop the turbine, and V_0 the speed which the turbine would acquire when the brake is quite taken off. The co-efficients F_0 and V_0 naturally vary with the height of the sluice-gate. The figures given in the column of revolutions "calculated," have been ascertained by means of this formula. Experiment A was made with a height of sluice-gate such that, the brake being quite off, the generator should make 960 revolutions per minute, and generate a current of 3 amperes. The receiver at Grenoble on this occasion developed 6 h.-p. at its brake, whilst the work absorbed by the generator (calculated by interpolation) was 11 h.-p., a figure which is almost identical with that obtained by the committee by the use of a different method. I would remark, in conclusion, that the equation $\frac{F}{F_0} \times \frac{V}{V_0} = 1$, is precisely the same as that which I found some years ago to represent in the simplest possible way the working conditions of an electric motor with constant magnetic field fed from a source of constant E.M.F. It will be seen from Experiment A that an increase of 5kg. in the weight produced a decrease in speed of 8 revolutions per minute, whatever was the weight on the brake."

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ELEMENTARY ELECTRICITY.—XIV.

If a piece of blotting paper be dipped in a solution of potassic iodide, and be placed at a distance of about a quarter of an inch from two sharp points connected with the electrodes of a Voss machine, or ordinary frictional electric machine, and kept two or three inches apart, when the machine is worked the current of electricity will stream from one of the points on to the paper, and from the paper to the other point. A brown stain produced by free iodine will then be seen upon the paper, opposite the point from which positive electricity streamed. This experiment shows that a current of electricity from an ordinary electric machine is capable of decomposing a metallic salt, and it was devised by Faraday to show that electrolytic decomposition does not require contact between metallic, or other solid, electrodes and the compound decomposed.

A familiar example of electro-chemical decomposition, or electrolysis, occurs in the now common process of electrotyping, or the production in copper of casts of various objects by electrolytic deposition. A very simple apparatus suitable for electrotyping small objects consists of a stoneware jar, partially filled with a saturated solution of sulphate of copper (bluestone), having crystals of the same salt suspended in a muslin bag within the solution. In this jar is placed a smaller jar of porous earthenware (or brown paper rolled into a hollow cylinder, and sealed at the bottom). The porous jar contains dilute sulphuric acid, in which is immersed an amalgamated zinc plate. To the top of the zinc plate is attached a piece of copper wire, the other extremity of which carries the object which is to be electrotyped. If this object is not itself a conductor of electricity its surface is covered with plumbago, care being taken that the plumbago extends as far as the copper wire, so as to allow of the conduction of electricity to the wire from every portion of the surface which is to be covered with copper. The object is immersed in the sulphate of copper solution, and a current is found to flow from the zinc through the sulphuric acid, the porous pot, and the sulphate of copper to the object which is to be electrotyped, and thence through the copper wire to the zinc plate. Immediately a deposit of copper begins to take place on the object close to the copper wire, and this deposit gradually extends over the whole surface of the object, becoming thicker as the current continues to flow. The arrangement, in fact, constitutes a single cell of Daniell's battery.

Speaking generally, we may say that when a current is made to flow through certain chemical compounds, such as dilute acids, saline solutions, &c., these compounds are decomposed into their elements, or into more simple substances. The operation is called *electrolysis*, the compound which is decomposed is the *electrolyte*, and the substances formed by the decomposition are *ions*. The conductor by which the current enters the electrolyte is called the *anode*, that by which it leaves it is the *cathode*. The *ion*, which appears at the anode, is sometimes called the *anion*, and that which appears at the kathode the *kathion*. This nomenclature was established by Faraday.

When the electrolyte is a simple binary compound, as, for example, silver chloride, the passage of a current separates it into its elementary constituents. It was by the electrolysis of the caustic alkalies that Sir Humphrey Davy prepared the metals of the alkalies (potassium and sodium). When the electrolyte is of more complex constitution the passage of the current is frequently accompanied by the separation of the electrolyte into two compounds.

When the electrolyte consists of more than one compound it often happens that the ions into which one of the compounds (the true electrolyte) is separated, react upon and decompose the other compound, so that it seems as if two sets of ions had been produced by the same current. This is called secondary action, and it frequently accompanies the electrolysis of a metallic salt in aqueous solution. For example, suppose we are electrolysing a solution of sodic sulphate, Na_2SO_4. We may suppose that the true electrolysis consists in the separation of this compound into metallic sodium, which appears at the negative pole, or kathode, and sulphion (SO_4), which appears at the positive pole, or anode. Now, the metallic sodium will decompose the water forming caustic soda and liberating hydrogen, thus,

$$Na_2 + 2H_2O = 2NaHO + H_2,$$

while the sulphion will also combine with water forming sulphuric acid and liberating oxygen, thus,

$$SO_4 + H_2O = H_2SO_4 + O.$$

Hence, as the result of the passage of the current, we find caustic soda and hydrogen liberated at the kathode, and sulphuric acid and oxygen at the anode, but the current is not to be held responsible for both these actions. The true electrolysis is the separation of the sodic sulphate into sodium and sulphion, and the decomposition of the water is a secondary and purely chemical action.

The great law of electrolysis, that of electro-chemical equivalents, was discovered by Faraday. This law may be briefly stated thus:—

If the same current be made to pass through several different electrolytes the amount of chemical action produced in each will be the same, and if the current be made to vary the amount of chemical action per second will be proportional to the current.

In more definite language, the law may be expressed as follows:—

If the same current be made to pass through several different electrolytes, the quantity of each ion produced will be proportional to its *combining weight* divided by its *valency*, and if the current vary the quantity of each ion liberated per second will be proportional to the current.

Thus, if the electrolyte consist of fused potassic chloride, fused silver chloride, copper sulphate, and dilute sulphuric acid, the electrodes in each case being platinum plates, for each gramme of hydrogen liberated in the sulphuric acid cell there will be 8 grammes of oxygen liberated from the sulphuric acid, 39 grammes of potassium and 35·5 of chlorine from the potassic chloride, 108 grammes of silver and 35·5 of chlorine from the silver chloride, and $\frac{1}{2}.63{\cdot}5$ or 31·7 grammes of copper and 49 of sulphuric acid from the copper sulphate, while 8 grammes of oxygen will escape from the copper sulphate solution, as the result of secondary action.

All electrolytes must be in the liquid condition. Metallic salts must either be fused or in solution.

An *apparent* exception to Faraday's law occurs when secondary action takes place, when it seems as if the same current decomposed two electrolytes and did double duty in the same cell, but this has already been explained.

The amount of hydrogen liberated in one second by a current of one ampere is about ·0000105 gramme, which may be taken as the electro-chemical equivalent of hydrogen. From this the amount of any other ion liberated by any given current in any time can be determined by Faraday's law.

Thus, chlorine being a monad element, the amount liberated per second by the unit of current would be 35·5 times ·0000105 grammes, since 35·5 is the equivalent of chlorine. Similarly the amount of sodium liberated would be 23 times that of hydrogen, and so on. Oxygen, on the other hand, being a dyad, the amount liberated would be only eight times that of hydrogen, though the equivalent of oxygen is 16. The cases of copper, zinc, and other dyad elements will be similar.

When an electric current passes through a solution of copper sulphate between two copper plates, there is a transference of copper in the direction of the current from one plate to the other, and from the principle above explained it follows that the quantity of copper so transferred is proportional to the whole quantity of electricity which passes through the solution. By weighing the plates before and after the experiment the quantity of copper transferred can be readily ascertained, and if the current has been constant, its strength can be determined, since a current of one ampere would in one second cause a transfer of 31·75 × ·0000105 gramme of copper. This method has for many years been

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practised in physical laboratories for the purpose of determining the strength of the currents which will produce a given deflection of a galvanometer. By replacing the copper plates and copper sulphate by zinc plates and zinc sulphate, we have Edison's electric meter, which is now used in order to determine the total quantity of electricity employed by a "consumer" in electric lighting during any period.

If a battery is employed to decompose dilute sulphuric acid with the evolution of oxygen and hydrogen, or to separate any other compound into its constituents, a definite amount of work must be done in decomposing the compound for every unit of electricity which passes through the electrolyte; for the passage of each unit of electricity corresponds to the decomposition of a definite quantity (one electro-chemical equivalent) of the compound. Now, the work which the battery is capable of doing in sending one unit of electricity round the circuit is represented by the electromotive force of the battery. Hence, in order that the battery may be capable of decomposing the compound, its electromotive force must be greater than the work required to decompose one electro-chemical equivalent of the compound—that is, greater than the mechanical equivalent of the heat produced in the union of the ions to form one electro-chemical equivalent of the compound. If several electrolytic cells are arranged in series, the electromotive force of the battery must be greater than the sum of the amounts of work necessary to decompose an electro-chemical equivalent of each of the electrolytes.

If the E.M.F. force of the battery be less than that required to fulfil the above condition no permanent current will be sent through the electrolyte. When the circuit is first completed a certain quantity of electricity will flow round it, and if a galvanometer be placed in the circuit the needle will give a sudden deflection, which will continually diminish, and very soon the current will cease. If the battery be now removed, and the electrodes of the electrolytic cell connected directly to the galvanometer, the needle will give a second deflection in the opposite direction to the first, which deflection will gradually diminish, but will not cease until a quantity of electricity has been sent round the circuit by the electrolytic cell in the opposite direction to the primary current, but equal in amount to that sent originally by the battery. Thus the cell has acquired for the moment the powers of a battery, and exerts an electromotive force opposite to that of the primary battery. The cell may be regarded as a secondary battery, and the electromotive force which it exerts is called the electromotive force of polarisation. If before discharging the electrolytic cell the plates forming its electrodes be removed and dipped into a second cell containing the same compound, but through which no current has been sent, it will be found that the plates will have conferred on the new cell the power of sending a temporary current; so that electrolytic polarisation is an action which takes place on the surface of the electrodes, and the electrodes themselves are said to be polarised. The polarisation appears to be due to the deposition on the surfaces of the electrodes of the ions in a *nascent* condition. It is this electromotive force of polarisation which balances that of the primary battery, and prevents a permenant current being sent through the electrolyte. The E.M.F. of polarisation cannot, however, attain a value greater than the amount of work necessary to decompose one electro-chemical equivalent of the electrolyte.

This experiment can be readily shown in the following manner:—Let two platinum plates having wires attached to them be dipped into a beaker of dilute sulphuric acid, care being taken that the plates do not touch one another. Connect one plate to the body of a Morse key and the other plate to one electrode of a galvanometer. Let the other electrode of the galvanometer be connected with the negative pole of a single Daniell cell, and also with the back cushion of the Morse key. Let the positive pole of the Daniell cell be connected with the front cushion of the key. Then, when the key is depressed so as to make contact with the front cushion, the battery, galvanometer, and electrolytic cell will all be connected *in series*, and a transitory current will be sent by the battery round the circuit. If the key be now released so that it makes contact with the back cushion, the battery will be thrown out of circuit, one of its poles being insulated, and the galvanometer will be connected in series with the electrolytic cell only. The inverse current above mentioned will then flow through the galvanometer, and both phenomena can be repeated as often as we please by depressing and then releasing the key.

When the battery is strong enough to send a permanent current, Ohm's law is obeyed equally by electrolytes as by conductors; but the electromotive force in the circuit is not the whole E.M.F. of the battery, but the E.M.F. of the battery diminished by the E.M.F. of polarisation set up in the electrolytic cell. Thus if E denote the E.M.F. of the battery, and e the greatest electromotive force of polarisation which the electrolyte can produce, and R the resistance of the circuit, the current C will be given by the equation—

$$C = \frac{E - e}{R}.$$

When a battery which is not sufficiently powerful to decompose an electrolyte is connected with platinum electrodes inserted in the liquid, a transient current passes, polarising the electrodes, and the passage of this current is associated with a transference of the ions to the platinum plates. There is, in fact, no evidence of the passage of any quantity of electricity through an electrolyte unaccompanied by the transfer of a corresponding amount of the ions. But though the transitory current from the battery is associated with the accumulation of the ions upon the platinum electrodes, it does not follow that the battery has performed the work of tearing asunder the electrolyte into its constituents. The molecules of every liquid must be regarded as moving about among each other, the average energy of the molecules being perfectly definite and depending only on the temperature. But though the average energy is definite, the energy of individual molecules may vary without limit, and thus it may happen that two molecules moving with far more than the average energy may come into collision, and the shock may split them into their individual atoms. These atoms will move on by themselves until they meet with others with which they can combine, reforming molecules of the electrolyte. The atoms thus separated are said to be "dissociated," and the percentage of dissociated atoms present increases with the temperature on account of the increase in the average energy of the moving molecules. Thus, in every electrolyte there is always a definite fraction of the whole compound in a state of dissociation, and this fraction will increase with the temperature. A battery may therefore be capable of separating these ions without doing the work of decomposing the compound. It has only to guide the different constituents to different destinations. If we suppose each atom of one constituent to be electrified positively, and each atom of the other to have a precisely equal, but negative charge, then the electromotive force acting between the platinum electrodes will urge the positively electrified constituent from the anode to the kathode, and the negatively electrified constituent in the opposite direction. This goes on until the accumulation of the electrified ions upon the surface of the electrodes introduces an opposing electromotive force equal to that of the battery, and stops the current. If the E.M.F. of the battery is so great as to allow of the accumulation of the ions in sufficient quantity, the nascent atoms combine into ordinary molecules of silver, chlorine, &c., but this only takes place when the E.M.F. of polarisation is equal to the energy developed in the combination of one electro-chemical equivalent of each of the constituents.

When the same battery is employed to send a current through several electrolytes in succession, the E.M.F. of the battery must be equal to the sum of the E.M.F.'s necessary for the decomposition of the electrolytes. When the E.M.F. between the electrodes exceeds that necessary for the decomposition of the electrolyte the excess of the work done by the battery is employed in heating the liquid according to Joule's law.

Daily Telegrams.—In 1870 the number of telegrams sent and received per day in London alone was 400 or thereabouts, now it is nearer 6,000.

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A NEW SYSTEM OF ELECTRIC TRAMWAYS.*

BY M. HOLROYD SMITH, C.E.

The proposal to lay tramways in Halifax excited my attention as an engineer, and as our town presents unusual difficulties, owing to the narrow, tortuous, and steep streets, it became necessary to consider the best means of coping with them. Horse traffic was, *prima facie*, out of the question, owing to the cost of horse flesh and cruelty to animals. Steam was questionable, first on account of the growing public objection thereto, and, secondly, the danger incident to running heavy engines up and down steep gradients in crowded streets. The cable system, though an admirable one in its way, and calculated to overcome the natural obstacles of a hilly district, seems in my opinion inapplicable, owing to the enormous outlay it would involve (many of our roadways being of solid rock), the great cost of working, and the small traffic to be expected. Pneumatic engines being open to objections similar to steam, my thoughts naturally turned to electricity. Such rapid strides have been made of late in the development of this wonderful agency that it has now arrived at that state when it may be considered amongst the numerous facts and forces at the disposal of the engineer. In endeavouring to make electricity practically applicable for the purpose named I started with the following propositions :—Firstly, safety to the public; secondly, protection of the electric force; thirdly, tractive efficiency. It is, perhaps, hardly necessary to remark that wherever the conductors are exposed, whether as rails or side bars, liability to accident exists; and, further, that not only is there a loss by leakage through the earth, but the line is also subject to be short circuited accidentally. The system advocated by Professors Ayrton and Perry, though probably admirable from an electrician's point of view, seems to me to be wanting in practicability and open to minor defects. Without discussing the sytems already tried it is perhaps sufficient to say that the propositions laid down seemed to me to have their solution in the simple expedient of employing a central channel to contain the wires or bands conveying the electric force, and effecting the haulage by means of a large wheel with a broad face running upon the surface of that channel. After carefully working out designs and making such calculations as lack of data permitted me to do, I proceeded to make experiments for the purpose of testing my theories. First, as to the comparative efficiency of the large wheel *versus* small ones. I laid a short length of rails in a warehouse with a flagstone floor, gauge 2ft. 9in., and constructed a rough truck with two small wheels and one large central one. The large wheel was 3ft. diameter, 6in. wide, and the two small ones were each 12in. diameter, $1\frac{1}{4}$in. wide. The truck weighed exactly half a ton, and was so proportioned that 5 cwt. came upon the large wheel and 5 cwt. upon the small wheels; both axles were fitted with gear so that either could be moved. To the end of the car a rope was tied, and passed under a pulley fixed to the ground, and thence over a pulley hung from a beam above. To the end of this rope weights were applied, and the small wheels made to revolve. The truck moving forward drew the rope and lifted the weights. The load was gradually increased until it reached 1cwt., when the wheels began to slip; at 1cwt. and 14lb. they simply revolved round and round and would lift no more. Motion was then transferred to the large wheel, and the weights again applied until the load reached 3cwt. 3qrs., when the tackle gave way, there being not the slightest slip. I considered this result sufficiently satisfactory to make it unnecessary to renew the tackle. My next experiment was also a rough one to test the possibility of collecting the electricity from the central channel and converting it into dynamic force to drive the large wheel. I therefore laid a line 50 yards long, 3ft. gauge, and placed upon it a rough truck, illustrated in Diagrams 1 and 2. The truck was simply made of rough planks, as illustrated, and was laid in the grounds of Moorside, the residence of L. J. Crossley, Esq., who kindly placed at my disposal his electrical apparatus and permitted me the use of his admirably-fitted workshop. Copper bands similar to those used for lightning conductors were laid within the channel, and upon them ran a wooden trolley, part of which I now show you. Connection was made between the trolley and the truck by means of a box or frame shutting upon it, the

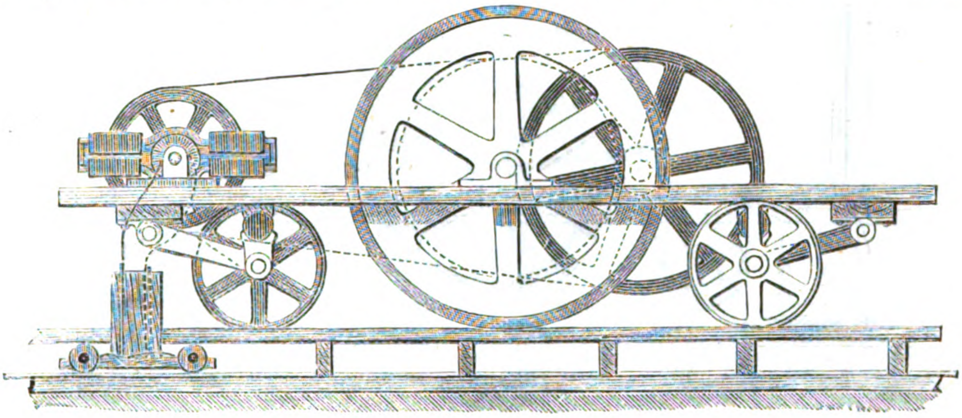

Fig. 1.—Side Elevation of Experimental Electric Truck.

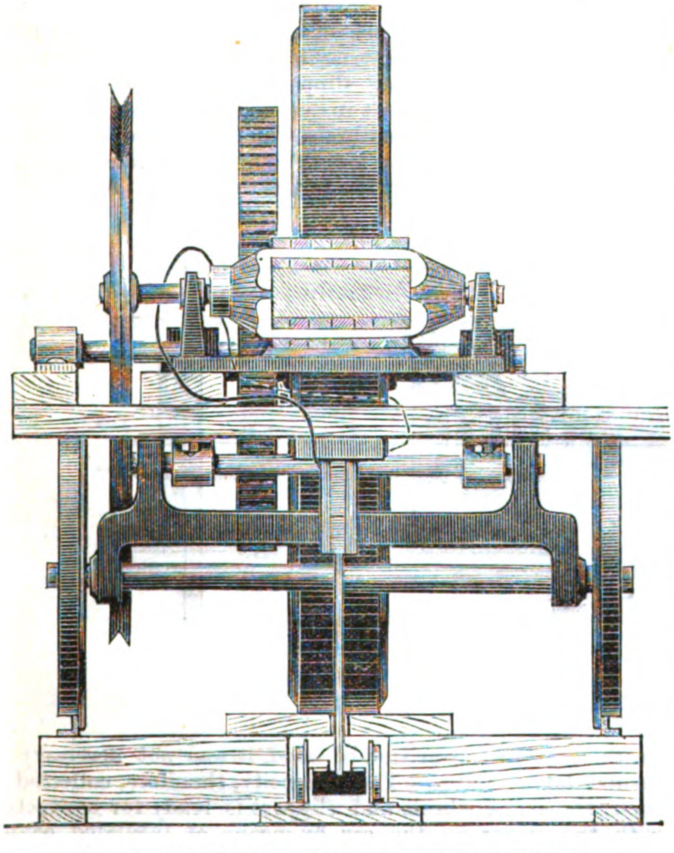

Fig. 2.—End Elevation of Experimental Electric Truck.

* Paper read before the British Association, Southport Meeting, September, 1883.

box used being here for examination. The car and gearing were of a rudimentary character, the main wheel was 4ft. diameter, 7in. wide. The electric motor employed in the first instance was one of Siemens's medium dynamos, but from some defect it would hardly revolve alone, though the electricity from a Gramme machine was conducted to it with little loss. I then took a Siemens D 3 dynamo, and modified the gear, and, though this was far too small a motor for such a load, viz., one ton, the whole mass moved slowly up the gradient of 1 in 20. This experiment was sufficiently satisfactory to forming the sides of the central channel, and with the two outer spars support the top boarding, which consists of cross planking, so laid as to leave half-inch space over the centre of the mid-channel. Every third board or covering plank is screwed down, the rest are nailed. This was done to facilitate removal in case of mishap. The tramrails consist merely of $1\frac{1}{4}$in. angle iron screwed to the surface of the planking. The conductors laid in this track consist of copper bands $\frac{3}{16}$ by $\frac{5}{16}$, brass discs are soldered to them at intervals. These discs have small holes punched in them,

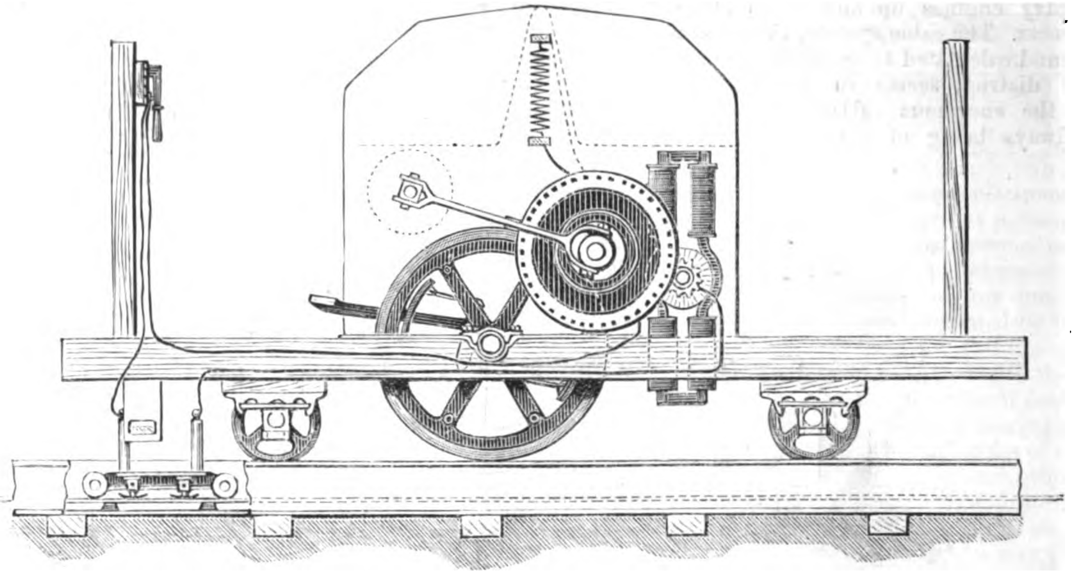

Fig. 3.—Section of Smith's Electric Tramcar.

ead me to further efforts; I therefore laid a fresh line nearly 100 yards in length up the same walk, gauge 18 inches, and made a car as illustrated in Diagrams 3 and 4. The same Siemens D 3 machine was employed as before. The gear consists of a brass pinion upon the axis of the dynamo, gearing into a lantern wheel, with wooden pegs in lieu of teeth. This wheel is free to revolve upon its shaft, and is fitted with a frictional clutch actuated by the two hand wheels, one on either side of the car. Upon the same shaft is keyed a pinion gearing, with and form a ready method of attaching the conducting bands to the bottom sleepers. The collecting trolley used is upon the table, and consists of two brass side frames insulated from each other by a block of wood. In each end of these fixings work guide or carrier wheels, and attached to the sides are cases containing slippers or skids free to rise and fall—this to insure contact in case of unevenness in the track or from vibration. Each brass frame has upon one end an upright plate or flat bar long enough and thin enough to pass through the slit in the top of the track. As the track

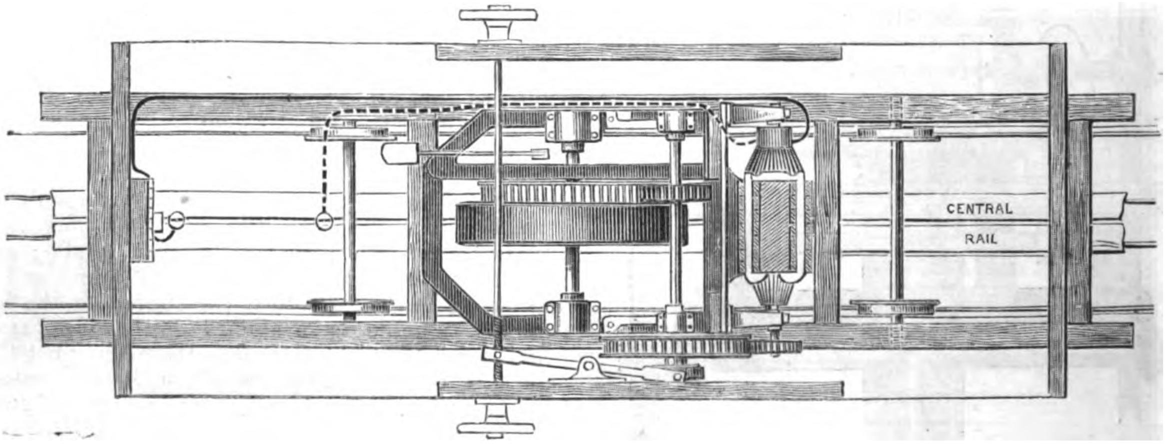

Fig. 4.—Plan of Smith's Electric Tramcar.

another lantern wheel attached to and forming part of the main driving wheel, which is 2ft. diameter and 4in. wide. The face of this driving wheel consists partly of wood and partly of a special material, to insure hold upon the central track. The brake is actuated by a treadle under the control of the driver's foot. The switch for connecting and disconnecting the electricity is attached to the dashboard in front. The track is constructed of planking, as shown in diagram No. 5, transverse sleepers are laid upon the asphalte walk, and upon them rest four longitudinal spars, the middle ones in this instance consisted of wood, it was not necessary to insulate these plates. The electricity, therefore, collected by their respective wheels and slippers is ready for connection with the motor on the car by means of insulated copper wires. This trolley is made to travel with the car by simply passing a wooden bar between the two upright plates, the bar being held in fixings attached to the side frames of the car. The entire weight of the car with dynamo and gear is 16cwt. The track, as before stated, is on a gradient averaging 1 in 22. I do not propose to give you a tabulated list of amperes,

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volts, and ohms, curves of results, &c. These matters are rendered sufficiently interesting by those who make them a speciality. It is, I assume, practical results that are most wished for, and I therefore content myself with saying that

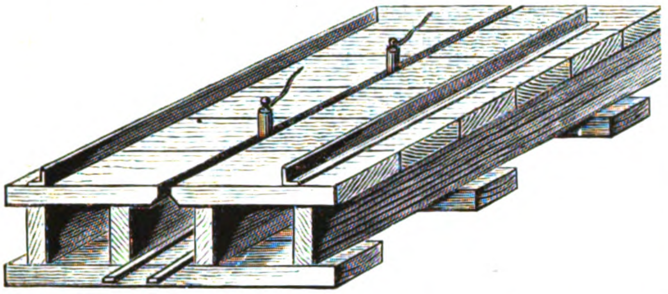

Fig. 5.—Showing Construction of the Track used for Electric Tramcar.

though it is as much as three men can do to push the empty car up this steep hill, yet the electricity was so collected and used as to run it up at a moderate speed with six adults in the car. Total weight, say 24cwt. It may be argued that the demonstration made is simply an experiment, and that there are many details inapplicable to daily work. Such a statement I am prepared at once to admit, viz., the demonstration so far is an experiment, but a most successful one.

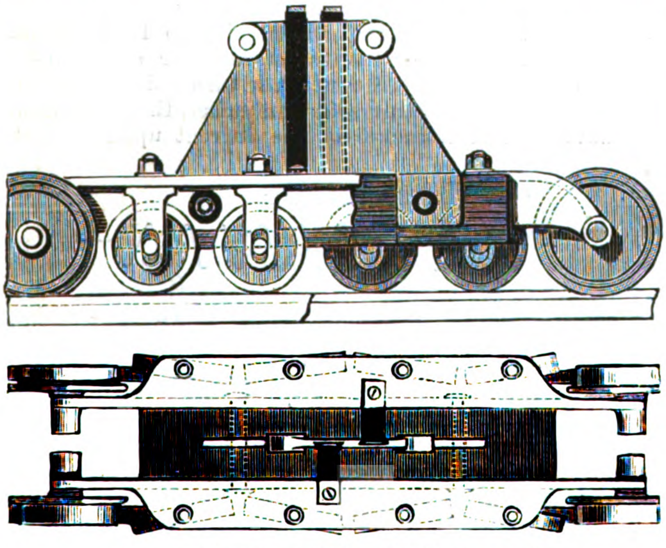

Fig. 7.—Elevation and Plan of Collecting Trolley.

And I now propose to show how some of the details may be modified for actual daily use on a large scale. In respect to the car itself, perhaps enough has been said to show the principle involved and its practicability. As to the best electric motor to be used, that I admit is a debatable subject. Though not professing to be an electrician, I must confess that no electric motor that has yet come under my notice fulfils what I conceive to be possible, or is constructed in a way calculated to make the best use of known forces. Again as to gear, though I took care to test by experiment the strength of the wooden pegs used in the lantern wheels, and found them practically applicable, and leaving sufficient margin of strength, and though their employment overcomes the objection of noise, and forms a wheel easily repaired by an ordinary mechanic, yet, owing to the high speed at which electric motors must necessarily run, I hold it advisable to employ some form of compound differential frictional gear, and have therefore made experiments to that end, but they are not yet sufficiently advanced to bring before the notice of this society. Again, as to the surface of the traction wheel, I confine myself to the statement that it is of special material. Experience alone must determine how far it is suitable for the wear and tear of every day work; therefore I refrain at present from giving a precise description. Respecting the track, though I have designed and patented many modifications thereof, it is perhaps sufficient to give a description of one, and this I have endeavoured to

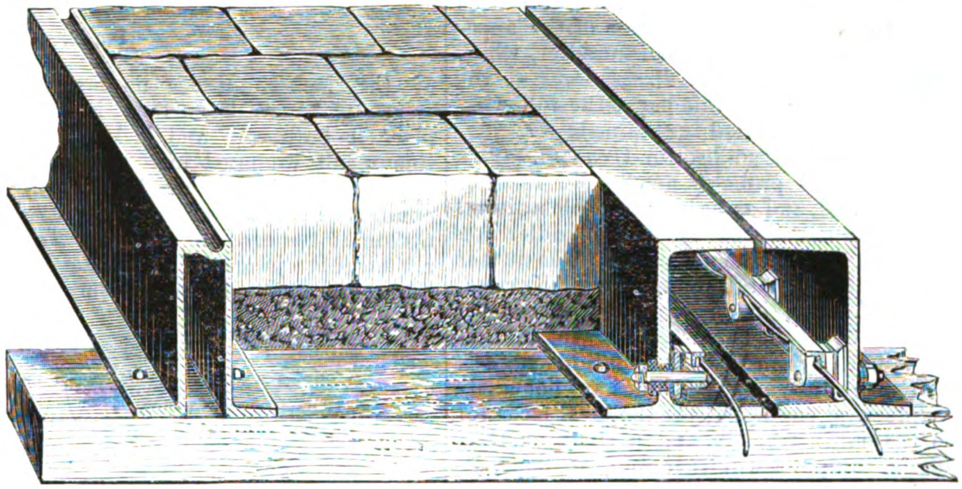

Fig. 6.—Section of proposed Tram Line on Smith's Patent, showing one rail and the central channel, with conductors.

illustrate by Diagram No. 6, which is a section of a tramway. The rails rest on transverse sleepers, and the central channel consists of rolled or cast-iron girders of the form shown. At intervals along the channel are bolted brass chairs on vulcanite blocks. These chairs are made to hold galvanised angle iron in the manner shown, and the same key that holds the angle iron also grips a copper wire. By this combination a firm track is formed for the trolley, and the electrical resistance is minimised. I would also point out that copper wires might be used only for the leading conductor, return circuit being made by means of the metal of the channel itself. Ribs or flanges could be rolled or cast upon them for the wheels of the trolley to run upon. Wells connected with the street drains are placed at intervals to collect and carry away any water that may accumulate, and also to permit of the channel being occasionally flushed. Respecting the trolley, upon the table will be found a drawing (Fig. 7) illustrating one suitable for a full sized line. The channel in which it would have to run being of iron, the upright plates are distinct from the side frames, and they have channels formed in them in which insulated copper bands attached respectively to each side frame are placed. The electricity can thus be gathered from the conductors and passed to the car without short circuiting through the channel. To ensure good contact with the conducting bands or rails, in addition to the guide wheels and in lieu of the slippers or skids, a number of wheels are placed down each side of the trolley. These wheels are free to rise and fall in their bearings, which are so attached to the frames that the axes of the wheels may be placed at any angle with the line of motion, thus causing frictional as well as rolling contact between the periphery of these wheels and

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the rails, the relation between the frictional and rolling contact being adjustable. I will not weary you with any further details, but take this opportunity of stating that, with the assistance of those associated with me, I am prepared to construct a full sized tram line in any public street, or to convert existing lines into electric lines in accordance with my system, and to guarantee success, and I sincerely hope before the next annual meeting of this honourable association to be able to report progress.

THE INTERNATIONAL ELECTRICAL EXHIBITION AT VIENNA.

(FROM OUR SPECIAL CORRESPONDENT.)

V.

Difficult as it is to find among this large display anything that is absolutely new, we found the model of a motor which to us was altogether new. Since first examining the apparatus we have been informed that a similar motor has been suggested in one or two quarters, but the model at Vienna was, as we say, new to us. A full description of the apparatus is contained in a paper by Professor Pfaundler, which appears in the March number of the *Proceedings* of the Vienna Academy of Science. From this paper the following description of the apparatus exhibited is obtained:—

THE KRAVOGL-PFAUNDLER RING-JACKET-DYNAMO.—This title for a dynamo machine is probably new to our readers, but it is the best we can find, and as near as possible a literal translation of the German name used by Mr. Pfaundler in a little pamphlet on a very remarkable machine.* The author compares the machines of Pacinotti, Gramme, and Kravogl, explaining their mode of action in an original manner from a point of view common to all the three, and showing in what essential parts they differ or coincide. Although his suggestions for the improvement of dynamo machines are not likely to find favour with practical engineers, yet the ideal basis for these suggestions is very instructive, and a short abstract from Mr. Pfaundler's pamphlet will therefore, we hope, be interesting to our readers.

Let in Fig. 1 a coil or solenoid be moved from left to

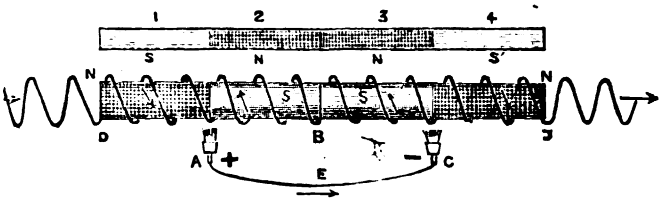

FIG. 1.

right over a magnetic core, then currents will be generated in the direction of the arrows. The same result, though to a smaller extent, can be obtained by moving the coil not over a core but alongside a bar of opposite polarity. But if the core and the bar be jointly employed, and especially if the bar take the form of a hollow cylinder (the jacket) surrounding the coil, then the possible maximum strength of currents will be obtained. In this manner we arrive at the principle of a magneto-electric apparatus, which consists of three parts—the core, the coils, and the jacket. Hitherto we have assumed both the core and the jacket to be permanent magnets; but this is not essential, for if one only be a permanent magnet, the other becomes an induced magnet, and so far nothing is altered in the arrangement of these parts. If the core be made of soft iron we have Pacinotti's machine; if the core be a permanent and stationary magnet, and the jacket be of soft iron, we have Kravogl's machine. In either we have one permanent and one induced magnet. It is evident that the permanent magnet might be replaced by an electro-magnet, but before entering on this the author considers the question as to how far the currents circulating in the coils affects the magnetism of the core. The apparatus shown in Fig. 1 must be imagined to be of circular form, though for clearness of illustration it is shown straight. If we divide the circle into four parts, D A, A B, B C, C D, numbered respectively 1, 2, 3, and 4, we find that by Lenz's law the currents in 2 and 4 tend to increase, those in 1 and 3 tend equally to decrease the magnetism of the core as well as that

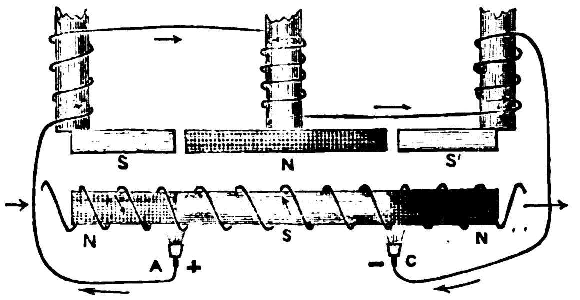

FIG. 2.

of the jacket. Hence no mutual accumulation and increase of a weak current into a strong one can take place if both core and jacket be of soft iron. To obtain this result we must introduce some modification into the apparatus, and that can be done in two ways. Either we eliminate that part of the current which weakens the magnetism of the core (Kravogl), or we add to the useful magnetism of the jacket, and by induction also to that of the core (Gramme). The latter system is shown in Fig. 2, and is

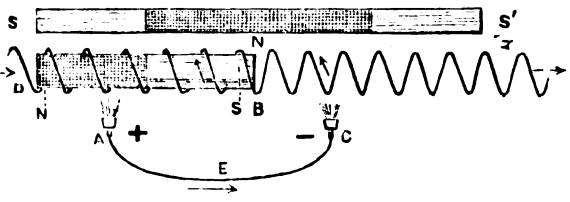

FIG. 3.

nothing else than the usual dynamo-electric machine. The former system is shown in Fig. 3. Here half the core (on the right hand side) is taken away, and it is supposed that the brushes and their connections be so arranged that only the current due to Parts 2 and 3 is collected. This current transforms the stationary soft iron core into a magnet, N S, which in turn induces stationary poles, S N, in the rotating soft iron jacket, thereby lessening the unfavourable influence of the current upon the jacket.

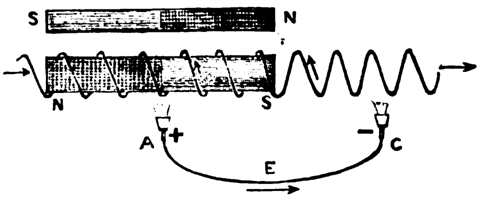

FIG. 4.

This arrangement is dynamo electric, but it still contains a defect. The current, although magnetising the core in the desired manner, affects the jacket somewhat disadvantageously, inasmuch as it tends to displace the pole N to the right end of the jacket. This evil is partly counteracted by the strong influence of the pole S, but not totally eliminated. For this reason it would be better to reduce the length of the jacket by taking away the piece B D. If this be done the jacket cannot revolve with the coils as in the former case, but it must be held

* Ueber die Mantelring maschine von Kravogl und deren Verhältuiss zur Maschine von Pacinotti-Gramme nebst Vorschlägen zur Construction verbesserter dynamo-elektrischer Maschinen.—Sitzb. der K. Akad. d. Wissensch. März-Heft, 1883.

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stationary and opposite the core. We arrive thus at the very simple form of dynamo electric machine shown in Fig. 4. An endless circular coil (shown straightened out in the diagram) revolves *over* a semi-circular soft iron core, and *through* a semi-circular soft iron jacket, both being stationary. The jacket must be understood to have a slot on its inner side permitting the spokes of the wheel which carries the coil and the wires connecting the different sections of the coil with the commutator to pass through. The brushes are so arranged that they only collect those currents which are generated in the sections whilst passing from a neutral point to a pole, but not when passing from a pole to a neutral point. Neglecting for the present the many practical difficulties of such a design, it is evident that we have thus arrived at a machine which is electrically perfect, because the principle of mutual accumulation is here carried to its utmost possible limit. All the currents generated tend to strengthen, and not, as is partially the case in the Gramme machine, to weaken the magnetism of the core; and, conversely, every magnetic pole in the system acts in the right sense for the increase of the current which originally excited it. The circular arrangement is shown in Fig. 5, where N N S S is the jacket (shown in section), and S O N the inner core. It is assumed that the core be provided with rollers which run on the inside of the tube carrying the coils. The core is

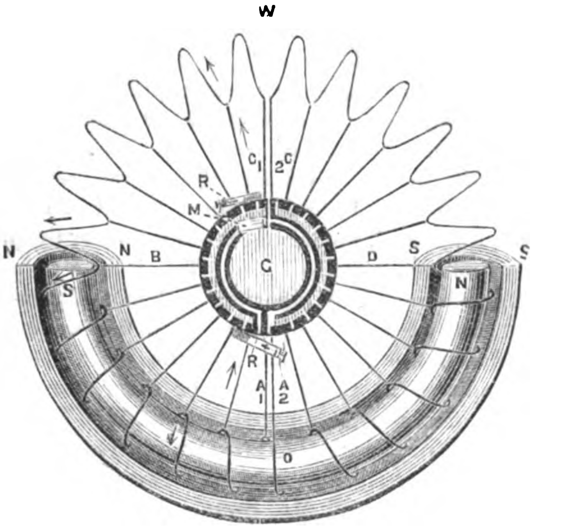

Fig. 5.

kept stationary by its own weight though slightly displaced to the right or left according to the direction in which the coils revolve. The jacket is then fixed in line with the core, that is with an equal displacement. In order to cut those coils out of the circuit which at any given moment move from a pole to a neutral point, a somewhat altered form of commutator must be employed. Two opposite plates of the ordinary Gramme commutator are each divided into two halves insulated from each other. One of these halves is connected with the end of one coil, the other with the beginning of the next coil, as shown in Fig. 5 in $C^1 C^2$ and $A^1 A^2$. Each half has also an extension in the shape of a semi-circular strip bedded in insulating material on the outer surface of the commutator (these strips are shown in the diagram on the endface of commutator), and the brush M serves to bring these strips into contact at the right moment. It will be clear from the diagram that one pair of strips must always be under the brush M, whilst the other is not so bridged. In the part of the coil corresponding to the latter pair the current is therefore interrupted.

This is the principle of the Kravogl-Pfaundler machine, and in a foot note the author states that a machine of this description was at work in February, 1870. It was driven by water-power, the experiments being carried on in an engineering works near Tunsbruck, and witnessed by many. Measurements, however, were not taken.

CORRESPONDENCE.

INFORMATION WANTED *RE* AYRTON AND PERRY'S MOTORS, &c.

TO THE EDITOR OF THE ELECTRICIAN.

Sir: Would you kindly inform me if Professors Ayrton and Perry's motors can be bought, and the address of the maker. Also, how can the formulæ in Count du Moncel's "electro-magnets" be made applicable to magnets with a rectangular cross section.—Yours, &c., E. S.

THE ELECTRIC LAUNCH AT VIENNA.

TO THE EDITOR OF THE ELECTRICIAN.

Sir: I notice that an electric boat went fifty miles down the Danube in four hours. Is it known what the speed of the current was, and how long the boat took to complete the return journey?

More than once I have paddled the same distance in a less number of hours, but I never tried to come back.

The Rhone would be a good river to try electric launches on, because even steamboats have been known to do in 16 hours *down* stream, what they have failed to accomplish in 10 days when going against the current.—Yours, &c.,

Putney, 2nd October. Canoe.

EXPERIMENTS IN BOLOMETRY.*

BY PROF. SILVANUS P. THOMPSON.

Hitherto the bolometers devised by Langly and others have been constructed of thin films blackened with lamp black or platinum black. Abstract considerations show, however, that to have maximum degree of sensitiveness the conductor employed should be one in which the change of electric resistance per degree of temperature is the greatest; it should also have as small a thermal capacity as possible, and its exposed surface should be its only conducting part. Theoretically, therefore, a carbon film in some high conducting form should be the best. Pending the preparation of special carbon films the author had made some experiments on the strips and filaments of carbon which are to be found in incandescent lamps. The resistance of these when carefully measured on a Kirchhoff bridge was found to be considerably less when exposed to radiation than when kept in the dark, the change of resistance in some cases amounting to one per cent of the total resistance. The cylindrical filament and rectangular strips used in most lamps are not, however, well adapted to show the bolometric effect, as their exposed surface is small as compared with the area of the cross-section of the conductor. These observations suggest the following points (1) that measurements made for specifying the resistances of such lamps should be conducted in the dark; (2) that a carbon film or even a carbon lamp may serve as the receiving part of a photophone; (3) that probably the effects obtained by Dr. Börnstein with metals might be re-observed if the metal films were very thin; (4) that special films of good conducting carbon should be applied in standard bolometers; (5) that a time standard photometer might be constructed on the bolometric principle, having the sensitive conducting film covered with *pigmentum nigrum* from the human eye. Such an instrument ought to be sensitive to precisely the same rays as the eye itself, and in identically relative proportions for different rays.

* Paper read before the British Association, Southport Meeting, September, 1883.

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THE ELECTRICIAN.

TO CORRESPONDENTS.

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ANSWERS TO CORRESPONDENTS.

——— . *Before answering your letter, we would ask you to read the notice at the head of this column. You will then understand why your question has not been answered in this number.*

J. M. PHILLIPS.—*The German book on electrolysis, &c., is not published in English.*

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AMALGAMATION.

It will surprise nobody, though it may alarm not a few, that the two most formidable competitors for incandescent electric lighting have determined to amalgamate. Their friends and enemies alike will regard this union of their forces as a guarantee of permanent strength and stability, whilst to the parties most nearly concerned it is a welcome signal of peace. For our own part, we cannot help congratulating not only the shareholders of the respective companies but the public at large on the improved prospect for indoor and domestic electric lighting which this amalgamation foreshadows. What may come of it cannot be very confidently predicted at present, and of course we reserve our right to comment upon the future action of the new management; but to all appearance the step now taken is a wise one, and if judiciously followed up can hardly fail to prove highly beneficial.

Ever since the new departure was made in the matter of incandescent lighting by Mr. Swan in this country and Mr. Edison in America it has been plain that for a certain class of illumination, and this a very important one, the inventions identified with the names of the two persons just mentioned would practically share between them the supply of that class of light, to the eventual exclusion of any probable rival. So far as England is concerned, this has certainly been the case, such competition as has so far sprung up, though attended with some inconvenience to the original promoters, not seriously threatening their final ascendancy. This kind of competition, however, might always be looked for, and, to begin with, it was obviously desirable to strengthen their joint position so as to overpower any dangerous rival. But their chief danger was from rivalry with each other. Their respective positions in this relation have been particularly accentuated by the legislation of last year, and by the rules framed in the Government Department charged with carrying it out. One chief aim of that Department appears to be to encourage and promote competition to the utmost; it is neither surprising nor regrettable that the effect has really been to set on foot a scheme of amalgamation the first consequences of which will be a cessation of competition.

In competing against each other for the lighting of various districts under the Electric Lighting Act, the Swan Company on the one hand and the Edison Company on the other soon discovered that their opposition was sufficiently powerful to damage both, and sometimes without substantial benefit to either. This, no doubt, has been one prime cause of the amalgamation, though, naturally, it was not referred to at the public meetings. Indeed, so far as the Swan Company's meeting is concerned, no arguments in favour of the proposal were either offered or asked for. The Edison Company is not on English lines, and reporters were not admitted to its meeting. But we may conjecture that the same reasons which induced the shareholders of the Swan Company to silently acquiesce in the proposal of their directors were equally convincing to the representatives of the Edison Company. It was remarked that the only persons dissatisfied with the terms agreed upon were the two representative inventors—Mr. Edison and Mr. Swan. We cannot vouch for the truth of this; but we venture to observe that it is not to the permanent interest of any inventor to be attached to an undertaking that does not pay its way. It was virtually admitted in respect to at least one of the undertakings in question that its profits must be spoken of under reserve; which means, we suppose, that the business has not been remunerative enough to boast about. Yet it is considered certain that such a business ought to be profitable; and in the opinion of the promoters of the new company about to be formed, under the title of the Edison and Swan United Electric Company (Limited), it can be made so if the two chief rival companies agree to work together.

There was, however, one other fact referred to by the chairman of Swan Company's meeting which has, no doubt, had considerable weight in paving the way for an understanding, and one which may prove fruitful of other settlements of a like kind elsewhere. We mean the insecurity of all patents relating to electric lighting appliances. They are just insecure enough to tempt an assault, but not sufficiently so to be certain of falling when assailed. The cost of litigation where a vast amount of capital is at stake on either side would be very serious. One or other of the parties might any day feel it necessary in self-defence to contest the rights of the other, and the party threatened would be bound to take up the challenge in fairness to the

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proprietors, and regardless of cost. Now, whether for the purposes of finally averting action of this kind against each other, or for making a combined stand against the action of any third party, the combination of the two great incandescent lighting companies is both prudent and timely. Add to this the obvious circumstance that they will be the better able to compete with the gas interests, which, after all, are the chief enemies to be feared, and we think the shareholders of the old companies, as well as the promoters of the new company, are to be congratulated on the bargain they have struck.

THE FISHERIES EXHIBITION.

In a previous impression we referred to a large double cylinder engine, or, rather, a pair of connected single cylinder engines working on one crank shaft, by which about one-third of the whole of the electric lighting plant of the Fisheries Exhibition is driven. This, like all the other engines, has been exhibited by Messrs. Davey, Paxman, and Co., of Colchester, and it has been purchased by the Government from this firm for the electric lighting of the South Kensington Museum. It is of about 400 indicated horse-power, and is illustrated by the engraving given above (Fig. 4), which is from a photograph taken from the public pathway in the engine and machine room. It is, perhaps, not obtained from the best position, but the engraving will serve to show the general construction of the engine and its chief parts. Often these engines are provided with condensers at the rear of the steam cylinders, but at the exhibition a sufficient supply of water was not available for the purpose. The engine is fitted with cylinders 18·5in. in diameter, the stroke being 32in., and the revolutions 68 per minute, steam at about 100lb. per square inch being used. The engine is fitted with Paxman's patent automatic cut-off gear, controlled by the governor, one governor controlling the cut-off in both cylinders. The cut-off gear consists of a small cut-off valve working over a number of small ports in a separate case, and by this means a comparatively small movement on the part of the governor is sufficient to make a very considerable difference in the period at which the steam is cut off in the cylinder, as the travel of the valve for opening all or closing the several narrow ports is of necessity but small. The valve is worked from a spindle which receives its motion from a slotted link connecting the rods of two expansion excentrics, the governors move this link up or down and permit the movement of one or the other excentric to dominate that of the valve, and so to change the period of cut off. The governors are also provided with a device by which their action on the slotted link may be adjusted so as to change the speed of the engine by from one to three revolutions while the engine is running. As an illustration of the action of this cut-off gear, we have seen three indicator diagrams, taken from an engine fitted with it. These show, in their order, that whether a very small quantity of work or a good deal of work is being performed by the engine, the cut off is rapid, equable and the approach to a theoretically perfect diagram maintained all through. At the Fisheries Exhibition the engine is provided with steam by boilers of the locomotive type, steel having been employed by Messrs. Paxman and Co. for this purpose for several years for fire-boxes as well as shells. The boilers, like the engines, are well made, the riveting being almost wholly performed by machines. Of the performance of the engines illustrated, no better proof is, perhaps, required than their purchase for the electric lighting of the South Kensington Museum, but as some experimental observations may be made with them before they are removed, we may be able to refer to the results in a future impression. The diagrams, Figs. 1 to 3 (p. 494), permit a clearer explanation of the automatic expansion valve arrangement. Fig. 1 shows in elevation the relative positions of the two expansion excentrics to that of crank pin. It will be seen that these have different travels, and are set at different angles to each other. The excentric having the longest travel is called the positive, that with the shortest travel the negative. It is the positive excentric which first operates on the expansion valve, admitting steam into the main

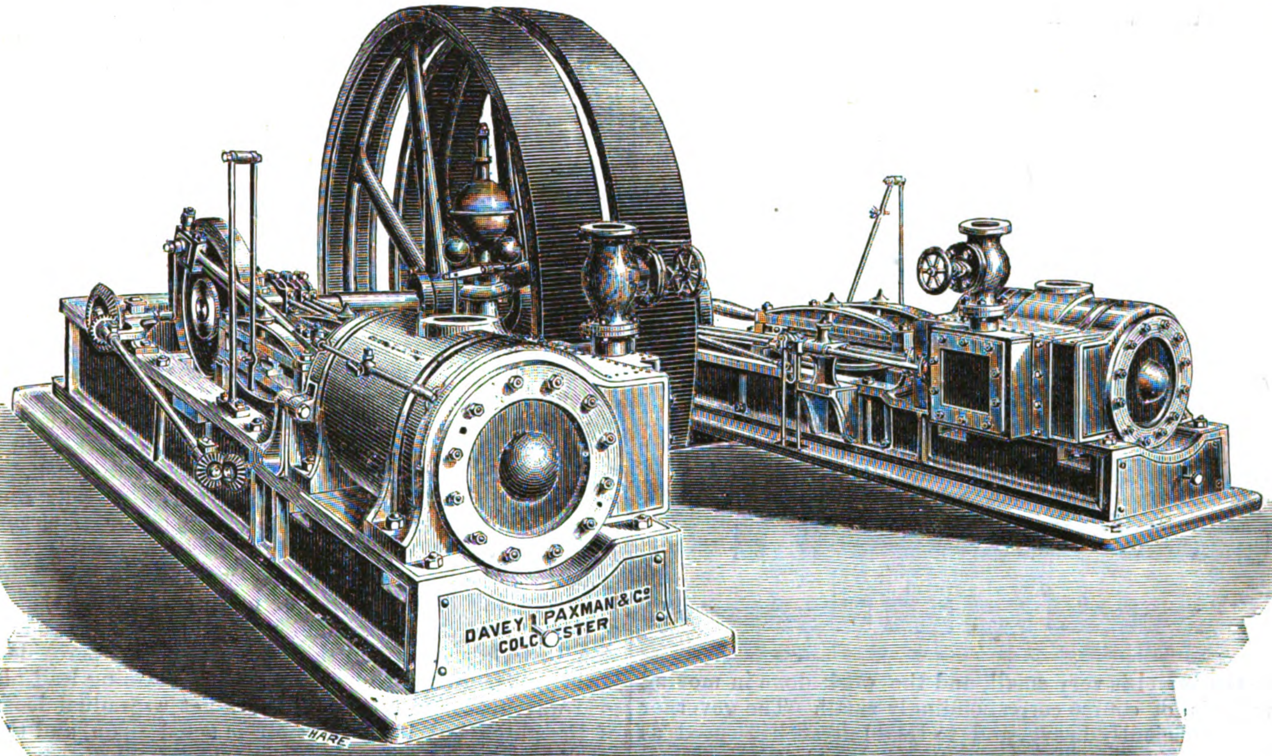

Fig. 4.

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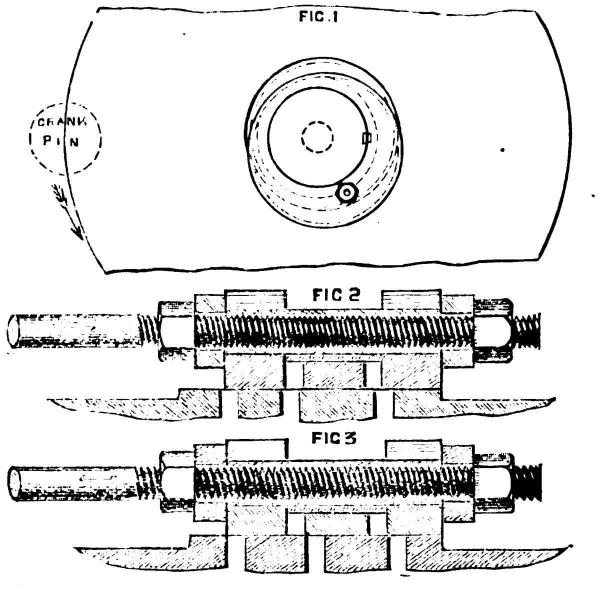
valve chest, the negative eccentric coming gradually into action as the expansion link is lifted up by the governors. With the crank in position, as shown by Fig. 1, and running in the direction indicated by an arrow; with the governor down, Fig. 2 shows the position of expansion valve, and the amount of lead. In this case the valve has the full travel of the positive eccentric, and the steam would be cut off at about three-fourths of the piston's stroke.

Fig. 3 shows the position of the valve when the governor is up, with the crank in same position as before. In this case the negative eccentric is in full action, and, as will be seen, is cutting off the steam at zero, the port having just opened a little before the end of the piston's stroke. Of course it will be understood that all other points of cut-off are obtained between these extremes according as the governor may move the expansion link higher or lower, the lead being constant. It will be noticed that the necessary travel of the positive eccentric is but small, owing chiefly to the arrangement of the gear, and the use of three passages provided for the admission of steam with corresponding openings in the slide. The diagrams obtained from this gear are excellent. It is an advantage that when the cut-off is about one third of the



stroke the travel is very small, and the work done in moving the valve is of course correspondingly small. The governor is made sufficiently heavy, and to travel at such a speed as to give a maximum variation of 3 per cent., but it is found in work with duty partially off and on to govern within ½ per cent.

SECONDARY BATTERIES; AND, AN ECONOMICAL METHOD OF GENERATING STEAM FOR ELECTRICAL AND OTHER PURPOSES.*

BY C. H. W. BIGGS, F.C.S., AND W. W. BEAUMONT, C.E.

Sir W. Siemens in his remarks upon a previous paper mentioned that information was needed as to the life of secondary batteries, and referred to results he had obtained. This paper deals with the results of experiments which have been carried out at the School of Electrical Engineering, principally under the direction of Messrs. Desmond G. Fitz-Gerald and T. J. Jones, by their assistants Messrs. Schiassi and Dornbusch.

It is not our intention to enter minutely into the theory of storage batteries, but rather to rapidly glance at the practical difficulties which have been met with in the attempts to develop the use of this apparatus. The popular mind holds to the idea that storage batteries have long been perfect, and wonders why they have not been far more extensively used. We hold that one of the first steps towards success is to know the causes of failure. Having found a cause we can then try to find a remedy. Some of the causes which operated against the immediate and extensive use of storage batteries are known, and various remedies have been and are being tried. A very brief reference to the principal batteries in use will enable us better to describe their faults. Without going back to older experiments, let us take the Planté form as a starting point. This consisted of lead plates opposed to each other forming the positive and negative plates of the cell, and rendered excessively porous by a long continued succession of charging and discharging, the charging current being at first often reversed. After charging, one plate was found to be covered to a greater or less depth with peroxide of lead, the other being pure lead or perhaps hydrogenised lead. Upon connecting the peroxidised plate by an external circuit with the opposite plate, the peroxide was reduced and the reduction accompanied by the phenomenon of a current of electricity. In order to obviate the time and energy lost in rendering the plates porous, M. Faure adopted the plan of coating lead plates with minium. This was found to give very favourable results, and the theory of this form of battery has been treated by Sir W. Thomson and Dr. Gladstone at previous meetings of the British Association. When, however, attempts were made to use this battery upon a practical scale certain faults were discovered, which led to modifications in the construction. The most recent type is that known as the Sellon-Volckmar-Faure battery. In this a plate of lead is cast somewhat in the shape of a gridiron. The holes in the plate are filled with minium flush to the surface. The plate has then to be formed, a comparatively simple and inexpensive process when compared with the Planté formation. Still, so far as we know, these various modifications have not led far towards perfection. It is found (1), and this is perhaps the greatest difficulty to be overcome, that during the action of the charging current and after the action, if the plates remain in the electrolyte the plates bulge or buckle, and this buckling frequently is so great as to cause the plates to touch. Then we have a "short circuit," and those plates or cells containing the short circuit are not only useless but are to be avoided at all hazard.

Besides the buckling tendency we have to guard against the loosening of the plugs of minium. Under the action of the current the formation of peroxide goes on, and expansion takes place. Upon the reduction of the peroxide there is the contraction. Now, even if the containing lead-plate or grid was not acted upon we should get a gradual loosening of the plugs, but the lead itself is acted upon, and the bad effect is hastened. The result is that the plugs drop out, or if they do not drop out, are loose, and the conductive continuity of the plate as a whole is weakened. One great aim in the construction of accumulators is to have the internal resistance as small as possible, therefore anything that increases this resistance is to be avoided.

The electro-chemical effects which have hitherto prevented the extended use of secondary batteries in electric lighting may be classified under two headings, viz.:

1. Those relating to the cathode or reducing pole in charging; and
2. Those relating to the anode or oxidising pole in charging.

The shortcomings to be referred to in the former category are, perhaps, more seriously detrimental than any other, since they interfere *ab initio* with the due working of the cells, whereas the other shortcomings lead merely to a certain loss of the electrical energy accumulated, and to the ultimate destruction of the anode pole within a period of time which is inconveniently limited. It will be recognised and admitted by all who have had practical experience in the construction and working of secondary batteries that the initial difficulties in obtaining a really efficient reducing pole have been far greater than those in connection with an oxidising pole initially efficient and gradually augmenting in efficiency until the final breakdown of the elements by the disintegration of the entire mass.

* Paper read before the British Association, Southport Meeting, September, 1883.

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Cathode (charging).

The difficulties in connection with the cathode element would appear in the usual forms of these batteries to have been almost entirely due to the use of a plate of lead in establishing contact with the active material, viz., sulphate of lead to be reduced in the operation of charging. In the first place sulphate of lead is reduced only with great difficulty and slowness by means of a lead cathode, especially when the electrolyte contains no constituent capable of holding in solution a portion of lead sulphate. Moreover, with an electrolyte of dilute sulphuric acid, lead and hydrogen are in such close proximity in the electro-chemical scale that a tendency exists to the electrolysis of the hydrogen compound (H_2SO_4) rather than to the electrolysis and reduction of the lead compound (sulphate of lead). The same tendency to the evolution of hydrogen which in the case of lead supports frequently results in an almost entire separation between the surface of these supports and the "active material," which should properly be in close contact with such surfaces, is no longer observed when a material, such as "carbon," strongly electro-negative to lead and hydrogen is employed in obtaining contact with the active material, nor have we very far to seek for the cause of this difference. It appears clearly to be traced to a "local action" which is active in the case of carbon.

If we suppose some portions of a carbon surface to be in close contact with lead sulphate, and other portions to be in direct contact with the fluid electrolyte, we may admit that the tendency to the evolution of hydrogen by the electrolysis of the hydrogen compound would be active mainly at the latter surfaces. Any hydrogen, however, separated by electrolysis would not be immediately evolved from the carbon surface, but would become "occluded" within the mass, rendering the surface in question powerfully electro-positive to carbon in its normal condition. Local currents would therefore be produced, due to the contact with each other and with an electrolyte, of two conductors which would be at a considerable distance from each other on the electro-chemical scale, and the effect of such local currents would be to bring about the recombination of the hydrogen liberated, and also a reduction of lead sulphate upon those portions of the carbon surface in close contact with the lead salt. In the case of the lead support no such local action could occur to any appreciable extent, by reason of the extreme weakness of the local currents which would be produced by the contact with each other, and with an electrolyte of lead "electroplated" with hydrogen and lead in its normal condition. In the plates with the ordinary lead support to the active material hydrogen is probably evolved as gas from the lead surface, and it will not be surprising that such evolution more or less completely breaks the connection between the support of metallic lead and the active material or layer of lead sulphate, which should be in the closest contact with it. Here, then, is another cause of weakness in a battery wherein the supporting material is lead, and we have every reason to believe that the use of carbon, as introduced by Messrs. Desmond FitzGerald and Jones, will prove an effective remedy. At least, results of experiments carried out during the past two years, both on a small and a large scale, have been very satisfactory. But there are other reasons why lead supports are unsatisfactory; for instance, the surface of contact with the active material appears altogether insufficient when it is compared with the surface of contact obtained by saturating carbon fragments with lead sulphate, and (preferably) filling up the interstices with similar active material. The objection that the lead supporting plate is liable during the running down of the secondary couple to become more or less completely coated with a coherent film of lead sulphate, which film, in the subsequent operation of charging, becomes detached by the action of the hydrogen liberated (initially in very minute quantities) at the surface of the metal, is of course entirely inapplicable in the case of the carbon surface. If the considerations advanced are correct, the substitution of carbon for lead as the conductor or support for obtaining contact with the active material at the cathode or reducing pole is a very important improvement in the construction of secondary batteries. It must be mentioned that any similar use of carbon at the anode or oxidising pole is not only detrimental, but absolutely destructive to the efficiency of the secondary couple based upon the electro-chemical reaction between metallic lead and the peroxide of the metal. It does not appear to be generally known, even amongst those who should know better, and therefore we hardly expect it to be known by the thousand and one dabblers in applied electricity who appeal so continuously to the Patent Office, that it is impossible to produce a layer of lead peroxide in contact with carbon, and *à fortiori* in contact with any more oxidisable material such as copper. Thus, those who have from time to time suggested the use of carbon in secondary batteries have implicitly or explicitly assumed or intimated that this material is applicable equally to the cathode and to the anode. Experiments upon a large scale, giving results absolutely negative from a practical point of view, have completely demonstrated the fallacy of such an assumption.

A question will probably present itself to many minds, and may, perhaps, be at once answered. It might with some reason be supposed that a carbon surface, coated with reduced lead, would be electro-negative to a lead surface coated with the same material, and if this were the case the fact would certainly constitute a drawback to the use of carbon, for we cannot afford to sacrifice even a small percentage of the electromotive force which is ordinarily developed in secondary batteries of the Planté or Faure type. The result of a large number of experiments has, however, been to show that (until the couple is almost completely run down) the E.M.F. obtained from an element of lead reduced upon a surface of carbon, such element being opposed to a plate of lead with its surface peroxidised, is quite equal to that obtained with an element of lead reduced upon lead and similarly opposed by a surface of lead peroxide. Indeed, for some reason which we cannot as yet explain, the lead reduced upon carbon nearly invariably gives an E.M.F. very slightly higher than that obtained with the elements wholly composed of lead.

Anode Element (Charging).

We have thus far dealt somewhat exhaustively with the cathode and the recent attempts to improve it. Giving the reasons which led to these attempts, and stating that the results have thus far proved satisfactory, we must now turn our attention to the anode in charging. The electro-chemical difficulties in connection with the anode may be referred to the fact that peroxide of lead, the most electro-negative of all conductors, forms a local couple with the lead support with which, as well as with the electrolyte, it is in contact. The action of the local current, as is well understood, is to convert the metallic lead into lead sulphate, or lead oxide, and to reduce the lead peroxide to a lower stage of oxidation. The detrimental effect of this action is two-fold. The couple when charged tends to "run down" with considerable rapidity, by the production of local currents, at the expense of the peroxide of lead and the lead conductor in contact with it. Most secondary batteries, as at present constructed, cannot therefore be left at rest after charging without some appreciable loss in the quantity of lead peroxide—that is, in the quantity of electrical energy accumulated. Indeed, the local action goes on to some extent *pari passu* with the action producing the current in the external circuit. This local action results in a very limited period in the complete disintegration, and consequent destruction, of the element, no portion of which is left unaltered to maintain efficient contact with the mass of peroxide. This is the same as saying that the Planté plate when giving its best result is upon the verge of destruction when it is wholly porous, and when it is completely peroxidised then it is useless. A portion of lead must be left to act as the conductor and contact piece. The improvements then in the anode tend to allow it to retain its charge for days and weeks with but a small percentage of loss in the energy accumulated. The accumulation of energy should, unless drawn upon, be practically permanent, and this would lengthen the life of the plate, and avoid frequent inspections and renewals. There would appear to be only two possible means by which the local action in a charged-up anode can be effectively decreased, and the life of the anode be considerably augmented. These means are (1) to oppose a resist-

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ance as great as possible to the passage of the local currents which tend to pass in the substance of the charged elements, and (2) to employ as the conductor in contact with the active material a substance decidedly electro-negative to ordinary lead, and therefore constituting a far less effective local couple with peroxide of lead than does metallic lead, whilst, at the same time, it is not subject to oxidation or disintegration.

Let us, then, consider briefly the use of impervious non-conducting materials in preventing local action in the element which is the anode in charging.

Let us suppose that we take as our anode plate (charging) a sheet of lead of any required size, and about $\frac{3}{32}$in. or $\frac{1}{8}$in. thick (rendered spongy wholly or in part by minute perforations), a form experimented with by the writers during the past two years. Minute perforations can be machine made. If used at once as an anode without preserving precautions, this element would rapidly improve up to a certain point, when it would rapidly deteriorate by reason of defective contact with the peroxidised material resulting from the almost complete conversion with peroxide of the metallic mass. Now let us suppose, as was first suggested by Mr. FitzGerald, that the surface of the lead is in part protected by a sheet of impervious non-conducting material perforated with apertures, and strongly adherent to the metallic surface.

A suitable material for this protective covering should be detrimentally acted upon neither chemically by the electrolyte nor electro-chemically by the effect of the current upon the latter. In the operation of charging, the exposed portions of the plate would immediately be attacked, and we may suppose the conversion taking place at these portions to have extended quite through the substance of the plate. The element would then be constituted by masses of lead peroxide supported in frames or in a lattice of metallic lead. Some amount of local action will undoubtedly take place between the lead peroxide formed and the metallic substance of the frames or lattice. In the local circuits the current passes from the unaltered metal to the electrolyte, and thence back to the metal through the peroxide. The electro-chemical effect will vary directly as the E.M.F. between the lead and lead peroxide, and inversely as the resistance to the passage of the local currents. It will result in the conversion of the metal into lead sulphate or oxide, and in the reduction of a portion of the peroxide to a lower degree of oxidation. But it is easy to perceive that as this local action extends laterally in the direction of the plane of the plate, the resistance to the passage of the local currents will become enormously augmented, mainly by the diminution of the quantity of the electrolyte which is present in the path of these circuits; and when we consider that the depth to which the conversion produced by these currents must extend under these conditions of resistance in order to operate (the destruction of the metallic frames or lattice may be made very considerable, say from $\frac{1}{4}$in. to $\frac{3}{4}$in. of metal to be converted), it becomes easy to realise that the life of an element so constructed may be vastly extended. When, in fact, the destructive action has extended laterally to a depth of some 1-16in. along the interior surface of the protective covering, the action seems to be almost arrested. A secondary battery, constructed with such anodes, may, *when fully charged*, be left to rest days or even weeks without appreciable loss. After such period of rest it is expedient, if not absolutely necessary, to pass a charging current through the battery during a few minutes, in order to convert into peroxide the minute quantities of lead sulphate or oxide which may have been produced by local action. By adopting this precaution the resistance is increased, but the increase is very small, and not at all comparable with what it would be if the same course was adopted with the cathode. It is well understood, in fact, that the surface of the anode in charging may be made somewhat less than that of the cathode without any appreciable detriment. The device of partly protecting the anode surface with a view to retain unaltered metal for support and contact with the active material, might, *primâ facie*, be regarded as crude and unsatisfactory. Our view is that the method is in reality based upon safe scientific principles, and this view has been confirmed by the experimental results obtained. The choice of materials to be employed for protective purposes is very limited. One of the best materials hitherto tried is that known as "Prout's glue."

With regard to the second device, the use of conductors electro-negative to lead for the support of the active material in the anode in charging, so that a comparatively ineffective local couple is formed to cause loss, the choice of material is very limited. A metal, such as copper, silver, or antimony, which forms a soluble sulphate by the effect of the electrolytic action is, of course, inadmissable. Carbon is also quite out of the question, not so much by reason of its rapid disintegration, but from the fact that lead peroxide reacts upon this element, and cannot electrically be produced in contact with it. Gold and platinum cannot be employed, not alone by reason of their expense, but because it is impossible to assume that strips or flakes of very minute thickness would be permanent under the conditions of practice. An alloy has, however, been found decidedly electro-negative to lead, and has given very encouraging results, but although we may be unable to say more in this direction, we have given our reasons for looking in this direction, and it may be that some chemist or electrician now present may be able to suggest a material which will answer the requirements.

(TO BE CONTINUED.)

THE MUNICH ELECTRICAL EXHIBITION.*

The Committee's Report on the Dynamos Shown.

The official report of the Munich Exhibition, which has just been published, contains the most circumstantial details under this head. The methods adopted in measuring are here described, all the operations of graduating the instruments are detailed with care, and the report contains not only the whole of the results obtained, but also all the figures relating to each observation in full detail. In a word, the whole register of the committee's experiments is reproduced in it. It will be understood that we cannot give it here in any such detail, and we shall content ourselves with publishing the tables of results given by each apparatus, giving first those obtained with the dynamo-electric machines, then those relating to the lamps. Further on will be found tables in which are given a *résumé* of the whole of the committee's observations and calculations. In extracting these tables from the report we have thought well to modify and suppress certain columns of figures which it does not appear to us to be necessary to reproduce. For instance, the current given by the different machines was measured at the same time by three instruments, a Wiedemann mirror galvanometer, Marcel Deprez's galvanometer, and Siemens's electro-dynamometer. The figures given by these different readings differed but little the one from the other, as may be seen from the following readings given by a Schuckert machine with different external resistances :—

	Wiedemann galvanometer.	Deprez galvanometer.	Electro-dynamometer.
I.	7·85	7·84	7·93
II.	7·81	7·94	7·90
III.	8·86	8·86	8·94
IV.	7·02	7·08	7·07
V.	7·42	7·41	7·50
VI.	9·02	9·09	9·13

From amongst these readings the committee adopted for their calculations that given by the Wiedemann galvanometer, but they none the less give the others, though we have not thought it worth while to do so. Similarly for the external resistance, although the committee in giving the value of this resistance as given by the rheostat which served to introduce it, adopt as final the value obtained form $\frac{e}{C}$, we give only this latter in the tables.

On the other hand, in several cases where the different observations made on the same machine have been carried out under similar conditions, with practically equal speeds and similar external resistances, we have only given the mean of the observations. Lastly, the report gives, and this in certain tables only, the relations $\frac{E}{n}$ and $\frac{n}{r+R}$ employed by M. Frölich; we have not thought fit to retain the columns giving the value of these

* From *La Lumière Electrique*, Sept. 8, 1883.

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relations. The figures given, moreover, permit of their being calculated, or of the construction of the characteristic of the machine in cases where the observations have been made with different currents.

The committee add to the results of their tests the following general remarks :—

The current is throughout expressed in amperes, the resistance in ohms, and the electromotive force in volts. . . . To measure the potential differences but one instrument was used, viz., the torsion galvamometer. The results given by it were, however, controlled by comparing the resistances introduced with the value shown for these by the expression $\frac{e}{C}$. For weak and average currents, this value is from 1 to 1·5 per cent. lower than the value of the resistance, but this must not be set down as the fault of the torsion galvanometer. For, on the one hand, it was ascertained that, under the influence of very strong currents, the resistance of iron wires had decreased by ½ to 1 per cent., and, on the other, it was to be supposed that, in the agitated air of the gallery, the wires of the rheostat became less heated than was taken into account in making the correcting calculation. With very strong currents the heating of the wire itself gave rise to a current of air, which tended to lower the temperature. Consequently, the temperature calculated for is too low, and the value of the resistance introduced is too high.

A particularly interesting matter is the work absorbed. Unfavourable circumstances, however, influenced in different ways the exactness of the measurements of work. These measurements might have been made with more ease and precision if the machines to be tested had all occupied the same position and been set in motion by the same motor, so far as possible by the same belts. The dynamometer would then have always worked under the same conditions. To move the machines was absolutely impracticable; the greater part of the time, within a quarter of an hour after the termination of the measurements, the machines were in use for exhibition purposes, and accordingly the Hefner-Alteneck dynamometer had always to be set up anew, often twice in a day. To the difficulties attending this constant shifting of the dynamometer, must be added the unstable condition of the ground, which trembled throughout a very extended radius when the belt traversed the dynamometer.

As might be expected, the relation $\frac{l}{A}$ f the external electrical work to the work transmitted by the motor is much more favourable with large than with small machines. The seven-light Schuckert machine gave as the value of this relation about 67 per cent., that at Hirschau 63 to 64, that of Schwerd 67, that of Bürgin's arc-lighter 63. Looked at from this point of view, therefore, the machines we have just mentioned very closely approach each other. Undoubtedly, the Edison sixty-light machine should be added, the relation $\frac{l}{A}$ for which was only obtained by the subtraction of the very considerable amount of work absorbed when working light. The quotient $\frac{l}{A}$ decreases with the size of the machine, and comes down to 52 per cent. for the Edison 17-light machine, to 43 per cent. for the Schœnemann machine (Gramme system), to 38 and 26 per cent. for the Edelman machines, and 23 per cent. for the Einstein machine. In this latter machine the small duty is probably due to the currents produced in the iron of the armature. On the other hand, the same economical qualities cannot be expected in small machines designed for laboratory experiments as in the large machines designed for work.

The passage which we have cut out above relates to the comparisons made between the galvanometric measurements indicated above. The editor of the report says on this subject in another part :—

The mean of the currents measured with the Deprez galvanometer is usually ½ per cent. higher than the mean of the measurements made with the mirror galvanometer. The two electro-dynamometers used are almost wholly in accord with one another, but their readings are about 1 per cent. higher than those of the other instruments. The cause of this unimportant difference may be subjective, and owing to the fact that, the machine currents being always somewhat undulatory, the observer has a tendency to turn the torsion head of the electro-dynamometers too far, which would not take place when dealing with the steady currents of batteries.

The cause of this difference may also be objective. Deprez's very mobile galvanometer affords the means of ascertaining that, besides the large irregular oscillations in the current, very small ones also occur periodically, and give to the needle a vibrating motion. From this it will readily be seen that, owing to these variations, the electro-dynamometer would give slightly higher readings than the other apparatus.

The observations relating to the working of the Hefner-Alteneck dynamometer may well be completed by the following remarks of M. Schroeter, who was specially charged with the manipulation of this apparatus :—

Under the circumstances in which we were placed, the principal qualities required of the dynamometer were :—Ease of adjustment, and equal safety of working within very wide limits of speed. The Hefner-Alteneck dynanometer answers, in a certain degree, better than any other to these two requirements, and if, in spite of this, some results of the experiments have been useless, it must be remembered that without this apparatus the carrying out of experiments in the space of four weeks would have been far from possible, and that the fault must be laid solely on the unfavourable conditions under which the instrument worked.

(Here the author gives a description of the apparatus, and the method of using it.)

At the end of the experiment the accuracy of the zero of the scale was verified anew. The facility and certainty with which this can be done comprise one of the many advantages of the Hefner dynamometer, for the longer and more difficult this matter is, the less ready is one to carry it out, particularly when time is precious, as in the present case. When the zero has been accurately obtained, the causes of error in the apparatus can, under favourable circumstances, be almost neglected; but to do this a very regular working motor is required, and no sticky or badly stitched belts, conditions which can easily be fulfilled under ordinary circumstances, but which in our case could not. Although the instrument behaved well, the thick parts of the belt, combined with the irregular working of the locomotive used as a motor, were the cause why the index could never be brought to a state of repose, and oscillated continually; with a little practice, it became possible, however, to regulate the index in such a manner that it oscillated equally on the two sides of the zero point, but it will be evident to all who have used the apparatus under similar conditions that errors may result in this way.

It was this circumstance which unfortunately influenced in an unfavourable manner that most important experiment, Deprez's transmission of energy, because as regards the generator, they had to do with a small tangential effort combined with a high speed and a low power little higher than 1 horse-power; at a belt speed of 15 metres, the difference of tension of the springs for 1 horse-power was 5 kilog., which corresponds on the scale to 2·5 mm. An error of a quarter of a millimetre in the reading gives, therefore, a difference of 10 per cent., and certainly under the conditions of the experiments the limit of error is still greater. It is greatly to be wished that the makers of the dynamometer will be good enough to remedy this evident defect by delivering with each apparatus a series of springs of different power, as has been long done with indicators. For each case a suitable spring could be chosen and would, in the first place, render the percentage of error in observation constant, and further, as small as could be wished. The large oscillations which are to be feared when using weak springs could be neglected by making the slackener so that it can be regulated.

We will now briefly pass in review the different machines which were tested.

Schuckert 7-light Machine.—It is to be remarked that between one brush and one terminal of this machine three inducing electro-magnets are placed, whilst the other electro-magnet is placed between the other brush and the second terminal. Its resistance cold is :—

Armature	4·945	ohm.
Magnets	6·370	,,
Total Resistance	11·33	,,

Schuckert Machine for Transmitting Energy.—This machine was placed near the Hirschau Falls. Its resistance cold was 20·73 ohms.

Schwerd 4 and 5-light Machine.—This machine is identical with that described above. The resistance cold is :—

Armature	1·144	ohms.
Magnets	1·848	,,
Total Resistance	2·969	,,

Bürgin Arc Machine.—This is the type of machine employed with Crompton lamps. Its resistance cold is :—

Armature	2·14	ohms.
Magnets	1·78	,,
Total Resistance	3·94	,,

The total resistance of this machine, measured directly, is slightly higher than the sum of the resistances of its two parts. The report attributes this to a small defect in the contacts during the measurement of the resistance of the armature.

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RESULTS OF EXPERIMENTS WITH VARIOUS DYNAMO MACHINES SHOWN AT MUNICH :—

—	Resistance of the machine warm. R	External Resistance. r	Total resistance. R+r	Current in amperes. C	Difference of potential at the terminals. e	Electromotive force. E	Electrical work. External l. eC	H.-P.	Total L. EC	H.-P.	No. of revolutions. n	Work transmitted, A, without deducting work when running light, in h.-p.	Returns. l/L	l/A	L/A
Schuckert Machine.															
Machine No. 389 for 7 arc lamps. External resistance of metal wires	13·60	56·31	69·91	7·42	417·6	518·5	3097	4·21	3845	5·22	898	6·83	80·6	61·6	76·5
	13·60	52·23	65·83	7·02	366·8	462·3	2576	3·50	3247	4·41	800	5·73	79·4	61·1	77·0
	13·25	46·89	60·14	7·81	366·0	469·4	2856	3·88	3663	4·98	801	6·20	78·0	62·6	83·3
	13·69	46·07	59·76	9·02	415·6	539·1	3750	5·10	4864	6·61	901	8·00	77·1	63·7	82·6
	13·14	34·03	47·17	8·83	300·4	416·4	2652	3·60	3675	4·99	702	5·74	72·2	62·8	87·0
The same machine with 7 lamps and resistance wires in the external circuit ...	—	50·86	—	7·85	399·1	—	3133	4·25	—	—	817	6·21	—	68·54	—
	—	50·45	—	8·00	403·5	—	3227	4·38	—	—	853	6·36	—	68·93	—
The same machine with one lamp and resistance wires in the external circuit ...	13·25	47·65	—	7·68	366·0	467·8	2311	3·82	3593	4·88	800	5·30	78·2	72·07	92·1
A T.L. 5 machine situate at the Falls of Hirschau	25·01	94·11	—	8·18	769·8	974·4	6297	8·56	7971	10·83	840	13·53	79·00	63·23	80·04
	25·28	89·75	—	8·43	756·6	969·7	6378	8·67	8175	11·11	840	13·50	78·03	64·19	82·27
Schwerd Machine.															
Four to five-light machine with four Schwerd-Scharnweber arc lamps in the external circuit	3·57	13·22	—	14·91	197·1	250·3	2939	3·99	3732	5·07	1000	5·84	78·7	68·4	86·8
	3·57	13·70	—	14·36	196·8	248·1	2826	3·84	3563	4·84	972	5·90	79·3	65·1	82·0
Same machine with wires as an external resistance	3·51	13·44	16·95	14·74	198·1	249·8	2919	3·97	3682	5·00	1012	5·90	79·3	67·2	84·8
	3·51	12·18	15·69	16·14	196·6	253·3	3174	4·31	4089	5·56	1018	6·42	77·6	67·2	86·6
	3·51	14·35	17·86	15·29	219·4	273·0	3354	4·56	4174	5·67	1107	6·85	80·4	66·5	82·8
Same machine with one lamp in the external circuit	3·3	13·50	—	16·11	217·4	270·6	3503	4·76	4359	5·92	1099	7·17	80·3	66·4	82·6
Same machine with wires as an external resistance	3·27	15·62	18·89	12·56	196·2	237·3	2463	3·35	2979	4·05	993	—	82·7	—	—
	3·27	17·48	20·75	11·30	197·4	234·3	2230	3·13	2647	3·60	998	—	84·3	—	—
	3·46	13·88	17·34	15·77	218·9	273·4	3451	4·69	4310	5·86	1108	—	80·1	—	—
	3·47	12·99	16·46	16·45	213·7	270·8	3514	4·77	4454	6·05	1099	—	78·9	—	—
Bürgin Machine, shown by Mr. Crompton.															
Machine for arc lamps, with three Crompton lamps in the external circuit	4·19	6·99	11·18	22·76	158·1	252·9	3578	4·86	5724	7·78	1622	8·83	62·5	55·0	88·1
	4·43	9·95	14·38	18·29	182·1	263·1	3331	4·53	4812	6·54	1601	7·61	69·2	59·5	85·9
	4·37	9·16	13·56	17·65	162·2	239·5	2862	3·89	4224	5·74	1492	6·70	67·8	58·0	85·7
Same machine with one lamp and resistance wires in the external circuit. Mean values of nine observations	4·3	10·42	—	16·34	170	240·2	2778	3·78	3926	5·34	1500	6·00	70·8	63·0	88·9
Same machine with one lamp and resistance wires in the external circuit. Mean values of three observations	4·46	10·68	—	16·64	177·6	251·0	2955	4·02	4190	5·69	1592	—	70·1	—	—
Machine for incandescent lamps, with wires as an external resistance	1·218	7·88	9·10	12·20	96·1	111·0	1174	1·59	1356	1·84	1397	—	86·6	—	—
	1·220	6·12	7·34	16·02	93·0	117·5	1572	2·13	1886	2·56	1398	—	83·4	—	—
	1·223	4·51	5·73	21·68	97·8	124·4	2129	2·88	2708	3·66	1410	—	78·7	—	—
	1·226	3·53	4·76	26·62	94·0	126·7	2518	3·40	3397	4·58	1406	—	74·2	—	—
	1·280	3·13	4·41	29·71	93·1	131·1	2785	3·76	3931	5·29	1405	—	71·0	—	—
	1·280	6·22	7·50	19·00	118·2	142·5	2252	3·05	2717	3·68	1600	—	83·0	—	—
	1·280	3·69	4·97	30·09	111·1	149·6	3366	4·54	4542	6·11	1595	—	74·3	—	—
	1·297	2·29	3·59	42·52	97·2	152·4	4195	5·62	6609	8·80	1588	—	63·8	—	—
The Schæfer (of Gœppingen) Machine—Weston Type.															
The external circuit being formed of wires	1·55	10·72	12·27	13·59	145·8	166·9	1981	2·69	2269	3·08	802	—	87·3	—	—
	1·58	8·92	10·50	16·85	150·3	176·9	2532	3·44	2930	4·05	792	—	85·0	—	—
	1·63	7·21	8·84	21·79	157·2	192·7	3425	4·65	4199	5·70	810	—	81·6	—	—
	1·73	5·20	6·93	28·79	149·7	199·5	4309	5·86	5744	7·80	795	—	75·0	—	—
	1·766	4·73	6·50	31·02	146·7	201·5	4549	6·18	6250	8·49	800	—	72·8	—	—
Same machine, with one Weston lamp in the circuit. Two observations gave.....	1·71	7·74	9·45	25·10	194·3	237·1	4879	6·63	5951	8·09	993	—	82·0	—	—
Schœnemann's Machine (constructed on the Gramme Workshop Model).															
The external circuit being composed of metal wires	1·292	6·13	7·42	8·26	50·65	61·32	418	·568	507	·688	1195	1·50	82·5	37·9	45·9
	1·368	2·80	4·17	15·89	44·46	66·24	707	·960	1053	1·430	1208	2·50	67·2	38·4	57·2
	1·403	4·13	5·53	15·15	62·52	83·78	947	1·287	1269	1·724	1500	3·00	74·6	42·9	57·5
Edelmann's Machine.															
Simple machine, with wires as an external circuit	5·17	14·56	19·73	4·18	60·89	82·49	255	·346	345	·469	1518	1·02	73·8	33·9	45·9
	5·23	11·79	17·02	5·10	60·08	85·74	[illegible]	·416	442	·600	1517	1·14	69·3	36·5	52·7
	5·32	8·97	14·29	6·15	55·17	87·93	340	·461	541	·735	1502	1·22	62·7	37·8	60·3
	5·41	7·08	12·49	7·05	49·85	87·99	351	·477	620	·842	1502	1·36	56·7	35·1	61·9
	5·53	5·24	10·77	8·05	42·20	86·75	340	·462	699	·949	1499	1·47	48·7	31·4	64·6
	5·86	4·25	10·11	8·74	37·19	88·43	325	·442	773	1·051	1508	1·56	42·1	28·3	67·3
	6·02	3·53	9·55	9·07	31·98	86·57	290	·394	785	1·067	1500	1·56	36·9	25·4	68·4
Double-wound machine. The two wires of the magnets and the two other parts of the ring being connected in series, metal wires as external resistance.........	8·29	15·39	23·68	3·23	49·74	76·53	160·8	·219	247·4	·336	1401	·93	65·0	23·5	36·2
	8·38	12·66	21·04	3·73	47·27	78·57	176·5	·240	293·4	·399	1401	·94	60·2	25·5	42·4
	8·47	10·79	19·26	4·12	44·40	79·25	182·7	.248	326·1	·443	1405	·94	56·0	26·4	47·1
	8·574	9·10	17·67	4·55	41·42	80·45	188·5	·256	366·2	·498	1403	1·01	51·5	25·4	49·3
	8·73	7·21	15·94	5·12	36·94	81·64	189·2	·257	418·1	·568	1404	1·07	45·3	24·0	53·1
	8·812	6·03	14·89	5·45	33·16	81·20	180·8	·246	442·7	·601	1402	1·11	40·8	22·1	54·2
	8·826	4·29	13·12	6·10	26·16	80·04	159·7	·217	488·5	·664	1405	1·17	32·7	18·5	56·7
Same machine with the two wires of the magnets and the two parts of the ring connected in shunt circuit; metal wires as external resistance.	2·18	4·36	6·54	3·66	15·71	23·69	57·5	·078	86·7	·118	1412	·61	66·1	12·8	19·3
	2·18	3·63	5·86	4·45	16·18	25·90	72·2	·098	115·5	·157	1400	·64	62·4	15·3	24·5
	2·18	2·50	4·68	6·43	15·84	29·86	101·9	·138	192·0	·261	1400	·79	53·1	17·5	32·9
	2·18	2·05	4·23	7·37	14·69	30·76	108·3	·147	226·7	·308	1400	·86	47·7	17·1	35·8
	2·18	1·57	3·75	8·28	12·53	30·50	103·3	·140	251·3	·341	1400	·91	41·1	15·4	37·5
	2·182	1·28	3·46	8·98	11·05	30·63	99·2	·135	275·0	·374	1400	1·03	36·1	13·1	36·3
Einstein Machine.															
The external circuit being formed by resistance wires	3·73	12·79	16·52	4·81	61·6	79·6	296	·403	383	·520	802	2·00	77·4	20·1	26·1
	3·77	10·82	14·59	5·55	60·1	81·0	334	·453	450	·611	795	2·08	74·2	21·8	29·4
	3·83	8·83	12·66	6·52	57·6	82·6	376	·511	539	·732	801	2·25	69·7	22·7	32·6
	3·92	7·04	10·96	7·75	54·5	84·8	422	·573	657	·893	802	2·45	64·2	23·4	36·4

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RESULTS OF EXPERIMENTS WITH EDISON MACHINES SHOWN AT MUNICH:—

—	Resistance, Warm. Of Armature R^1	Resistance, Warm. Of Magnets R^2	External resistance r	Current in the external circuit C	Current. In Armature C^1	Current. In Magnets C^2	Difference of potential at terminals e	Total electromotive force E	Electrical Work. External l Volt amperes.	External l H.P.	In armature Volt amperes.	In armature H.P.	In Magnets Volt amperes.	In Magnets H.P.	Total L Volt amperes.	Total L H.P.	No. of revolutions n	Work transmitted. $\frac{A}{H.P.}$	Returns. $\frac{l}{L}$	Returns. $\frac{l}{A}$	Returns. $\frac{L}{A}$
*K machine for 250 A lamps ...	·0416	13·84	1·298	100·6	110	9·4	130·6	135·2	13130	17·84	594	·68	1231	1·67	14870	20·20	914	—	88·4	—	—
	·0424	13·84	1·204	107·2	116·5	9·5	129·0	133·9	13830	18·78	575	·78	1202	1·63	15600	21·20	910	—	88·6	—	—
	·0444	13·85	1·034	123·2	132·4	9·2	127·4	133·3	15700	21·33	779	1·06	1171	1·59	17650	23·98	913	—	89·0	—	—
	·0471	13·86	·860	142·5	151·3	8·8	122·5	129·6	17450	23·70	1078	1·47	1082	1·47	19610	26·64	901	—	89·0	—	—
	·0496	13·87	·761	157·5	166·1	8·6	119·9	128·1	18880	25·65	1369	1·86	1036	1·41	21290	28·92	898	—	88·7	—	—
	·0517	13·88	·679	169·3	177·6	8·3	114·9	124·1	19450	26·42	1630	2·21	951	1·29	22030	29·93	880	—	88·3	—	—
*Z machine for 60 A lamps ...	·161	40·5	4·55	27·67	30 77	3·10	125·8	130·7	3480	4·73	152·2	·207	390·2	·530	4022	5·47	1197	8·83	86·5	53·5	61·9
	·164	40·6	4·12	30·12	33·17	3·05	121·0	129·5	3735	5·08	180·8	·246	378·4	·514	4294	5·84	1193	9·01	87·0	56·3	64·7
	·166	40·7	3·96	31·42	34·48	3·06	124·3	130·1	3907	5·31	197·9	·269	380·0	·516	4485	6·10	1198	9·37	87·1	56·7	65·0
	·171	40·8	3·48	34·31	37·24	2·93	119·5	125·8	4098	5·57	237·4	·323	349·9	·475	4685	6·37	1164	9·58	87·5	58·1	66·5
	·175	40·9	3·07	36·31	39·03	2·72	111·4	118·2	4044	5·49	266·1	·362	303·5	·412	4514	6·26	1109	9·36	87·7	58·7	67·0
	·177	40·9	2·82	37·69	40·29	2·60	106·3	113·4	4004	5·44	287·8	·391	275·7	·375	4568	6·20	1074	9·29	87·7	58·6	66·8
*E machine for 17 A lamps ...	·383	90·0	12·75	8·89	10·15	1·26	113·3	117·2	1007	1·369	39·5	·054	142·7	·194	1190	1·616	2409	2·98	84·7	45·9	54·2
	·399	90·4	10·93	10·34	11·59	1·25	113·0	117·6	1168	1·587	53·6	·073	141·2	·192	1363	1·852	2409	3·09	85·7	51·3	59·9
	·413	90·8	9·81	11·51	12·75	1·24	112·9	118·2	1300	1·766	67·3	·091	140·3	·191	1507	2·048	2409	3·39	86·2	52·0	60·3
	·406	90·6	10·29	10·94	12·18	1·24	112·5	117·5	1231	1·672	60·2	·082	139·7	·190	1430	1·944	2424	3·27	86·0	51·2	59·5

* Resistance wires as external circuit.

Schæfer (of Gœppingen) Machine.—This may be considered as a Weston machine, as it differs but little from one. The resistance cold is:—

Armature .... ·459 ohm.
Magnets........................ 1·051 „
Total resistance .... 1·498 „

Schœnemann Machine.—This is nothing more than a Gramme machine of workshop type made at Munich. It only differs from one in a few details. Its resistance cold is:—

Armature .... ·633 ohm.
Magnets........................ ·635 „
Total resistance .... 1·264 „

Edelmann Machine.—A small machine, designed principally for laboratory experiments. Its resistance cold is:—

Armature .... 2·548 ohms.
Magnets........................ 2·492 „
Total resistance .... 5·033 „

The work absorbed by this machine when working light was measured after the other observations. It was ·45 h.-p.

Double-wound Edelmann Machine.—Its resistance cold with the two windings in series was:—

Armature .... 3·274 ohms.
Magnets .... 4·717 „
Total resistance .... 7·991 „

Einstein Machine.—Its resistance is:—

Armature .... 1·516 ohms.
Magnets .... 2·150 „
Total resistance .... 3·620 „

Edison K Machine.—Large machine with six magnets. The measurement of the powerful currents from this machine necessitated special precautions. First of all, the whole of the measuring apparatus, with the exception of the mirror galvanometer, which was placed in shunt circuit with the copper wire, was taken out of circuit, and the two halves of the copper wire connected in quantity. From the very first tests it was seen that the first part of the large rheostat, that consisting of iron wire, must be cut out by means of a very thick wire, and, in the second part, consisting of copper wire, the wires expanded to such an extent that it was necessary to support them in a special manner to prevent their touching one another. The heating of the conductors, chiefly those that were covered, was so great that a wire of 4mm. diameter carbonised its insulation. The current was led to the testing laboratory by means of the thick naked copper wire, and the cable was used to take the difference of potential at the terminals.

The work should have been measured by the indicator of the machine, but this measurement could not, unhappily, be made at the same time as the electrical measurements. The work furnished by the machine was found to be 41·22 horse-power. If it be admitted that this work was equal to that furnished on the day when the electrical measurements were made, we should have

$$\frac{l}{A} = 64·1 \text{ per cent., and } \frac{L}{A} = 72·6 \text{ per cent.}$$

However, it must be remembered that the indicated work is always greater than the work transmitted. The resistance of the machine cold was:—

Armature .... ·0361 ohm.
Magnets .... 13·82 „

Edison Z Machine.—Has two large magnets for 60 lamps. The work absorbed when working light was 2·19 horse-power, which appears high, and which may, perhaps, be attributed to the tightness of the belts, which were very rigid. Deducting this figure from A, we shall have for the series of observations recorded in the table

$$\frac{L}{A - 2·19} - 82·3 - 85·5 - 84·9 - 86·2 - 87·4 - 87·4$$

$$\frac{l}{A - 2·19} - 71·2 - 74·4 - 73·9 - 75·4 - 76·6 - 76·6$$

Its resistance cold is:—

Armature........................ ·142 ohm.
Magnets .... 40 1 „

Edison E. Machine.—Small type for 17 lamps. Its resistance is:—

Armature........................ ·338 ohm.
Magnets .... 88·7 „

We shall not give too much weight to the comparison between the results obtained with these different machines. They are of too widely different types for this comparison to be of use, and it will be more profitable for the reader to compare the figures obtained for a particular machine with the results already known for existing machines. In any case, the committee's observations are particularly interesting in so far as they supply us for the first time with *bonâ fide* measurements made with two important machines, the Edison and Schuckert, which is being greatly developed in Germany.

DIRECT SPANISH TELEGRAPH COMPANY, LIMITED.

The twentieth ordinary general meeting of this Company was held at the offices, Leadenhall-buildings, Leadenhall-street, on the 28th ult., under the presidency of Mr. Neil Bannatyne.

The MANAGER (Mr. Ch. Gerhardi) read the advertisement calling the meeting, and the report of the directors was taken as read.

The CHAIRMAN then said that they had had the report and accounts in their hands for some little time, and no doubt had been able to go over them and satisfy themselves as to the position of the Company. He thought there was very little for him to add. In the second paragraph it was said, "The receipts may be considered satisfactory in view of the fact that the Bilbao capital was interrupted from the 14th January to the 23rd February, and again from the 9th March to the 2nd April." Well, notwithstanding that paragraph, he must say for himself that he was a little disappointed that the receipts were not larger when the cables were working, but he believed that that was attributable to the stagnant condition of trade throughout Spain during that period. This was more especially indicated by the falling off in the receipts of their Barcelona cable. The dulness was especially to be found in connection with business between the Stock Exchanges between Barcelona, Paris, Madrid, and elsewhere. While on the subject of traffics, he was glad to be able to say that their receipts for the first three months of this half year,

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especially for the current month of September, showed an improvement, and he thought they had every reason to expect that that improvement would continue to the end of the year. He trusted they would have no obstacle in the way of any interruption to their cables to prevent that prosperity from continuing. The receipts for July had been £1,372, for August £1,513, and for September (estimating for four days, the accounts of which they had to receive) £1,678, making a total of £4,563, or a decrease of £885 as compared with the corresponding period of last year. They had a very good half year last year as compared with the present year, but he trusted that the remaining three months would at all events come up to the corresponding three months of last year. During the six months ended the 30th of June the Company's own earnings were £3,148, and the balance received from the Eastern Company under the joint purse agreement was £1,731. The expenditure might be considered satisfactory, because they had charged £200 this half year as the cost of opening the London station and of removing the general offices. Taking the outlay into account the working expenses were only £26 more than in the previous half year, the only item showing any considerable increase being salaries and rent. That increase was attributable to the opening of the London station on the 1st of January, but it must be remembered, as compensation for the extra expenditure on the London station, that they had been able to put down a larger amount for telegrams than they would otherwise have done, as by having their own offices in London they only paid the Post Office the shilling rate per message on telegrams to or from the provinces, and, had they been at work during the whole half year, the total amount paid for the rent of wire to Falmouth, for the pneumatic tube with the central telegraph office, and for extra rent and salaries, would have been below the sum they would have had to pay the Post Office for telegrams collected and delivered in London. Besides that they naturally caused a development of traffic, which, however, would only be fully realised after the new arrangement had been in operation some further time. As mentioned in the report, they were able to work direct from the London station to Bilbao and Madrid without any intermediate transmission at Falmouth, where they were only obliged to keep a very small staff. As regarded the subject referred to in the third paragraph in the report, he went fully into the matter at the extraordinary general meeting which was called on the question of a duplicate cable, and he had nothing now to add to what was stated in the report. He concluded by moving "That the report and accounts now presented be and are hereby received and adopted."

Mr. Edmund Etlinger having seconded the motion,

Mr. Dyett assumed that nothing had happened to the Bilbao cable since it was reopened for traffic on the 27th of August?

The Chairman: No. In reply to the same shareholder he added that it was extremely difficult to say when they would be likely to commence laying the duplicate cable. It would very much depend on the state of the weather in the spring, and upon some other circumstances. If, moreover, they went on well, and had the prospect of paying a dividend on their Ordinary shares, they might see themselves in a position to make better terms for laying the cable than they otherwise would. They must be guided very much by their position. They were all of one opinion that as soon as it was found possible to lay the cable they should do it. They were, in fact, awaiting a good opportunity.

Mr. Dyett: It was not absolutely necessary.

The Chairman: It was not absolutely necessary as long as their cable worked, but when they could make themselves independent, as it were, by having a duplicate cable, the position of the Company would be very much improved and strengthened, as their receipts would then be kept up. No doubt shareholders were aware that they did not suffer as much as they did before from interruptions, owing to the arrangement with the Eastern Company for a joint-purse agreement. He might also add that they had received other advantages from the friendly connection and arrangements which they had entered into with the Eastern Company. For instance, they had had the interruption in August repaired at much less cost than ever before, or than they could have had the work done for but for their relations with the Eastern Company.

Mr. Dyett assumed that the Company did not make a loss during the 21 days that the Bilbao cable was interrupted in August, and that they were able to go on with their business.

The Chairman, in reply, stated that during the time the cable was interrupted they received their proportion of the receipts from the Eastern Company just as if their cable had been working. That was in accordance with their terms of working with the Eastern Company, who would receive their proportion of the receipts from this Company if their cable were interrupted. It was a mutually advantageous agreement. He then put the motion, and declared it carried. Continuing, he moved the following resolution:—"That the Preference dividend at the rate of 10 per cent per annum, less income tax, for the half year ended 30th June, 1883, be and is hereby now declared."

Mr. J. Denison Pender seconded the motion.

The Chairman, before putting the resolution, said that he and all the directors, of course, regretted very much that they were still not in a position to recommend the payment of a dividend on the Ordinary shares. As the report said: "After paying the dividend on the Preference shares, £3,000, and putting aside £200 to the reduction of preliminary expenses account, there remains a balance of £3,442 17s. 1d., which, looking to the repairs of the interruption of 6th August, it is proposed to carry to the reserve fund, that fund having been reduced to £820 18s. 11d., after providing for the repairs of the Bilbao cable in January, February, and March last." If they added the £820 to the balance of £3,442, they found a total of £4,263, which would be at the credit of the reserve fund at the date of the accounts. Out of that amount, however, they would have to pay for the repair of the Bilbao cable—for the interruption which occurred to that cable on the 6th August. After doing that he believed they would still have a balance to the credit of the reserve fund of a little above £2,000, so that if they went on for the next three months at the same rate, or, as was most probable, a better rate of progress than they had had during the first three months of the present half year, and if they had no interruption during the remainder of the year, they would earn during the present half year sufficient to pay the working expenses, the Preference dividend, and to have a balance over, which he thought would enable them to see their way not only to add a further sum to the reserve fund, but also to pay some dividend to the Ordinary shareholders. That, they would understand, was contingent upon their having no more interruptions during the half year, and surely they might hope that they would not have any more after their recent experience. After reading the resolution again for the payment of the Preference dividend, he said that he ought to have mentioned that they could not pay that dividend until they received the remittance from Spain for the quarter ended the 30th of June. That they hoped would reach them at the end of October.

A Shareholder inquired the reason for such a long time elapsing before they received the money.

The Chairman replied that it was according to the convention. The Spanish Government were not bound to pay the Company sooner—in fact, the Company were generally paid before they were entitled to be according to the convention. There were many other companies in the same position. As he had said at previous meetings, if they were in an affluent position, and had a large reserve fund of £10,000 or £12,000 out of which they could pay the dividend *pro tem* until they received their remittance from Spain, they would not ask the shareholders to wait. As it was they had no alternative, and as a Board they could not borrow the money to pay the dividend, as that would be unjust to the Ordinary shareholders. [A Voice: "Clearly."] The resolution was then carried unanimously.

On the motion of Mr. Dyett, who referred to the economic way in which the business of the Company was conducted, a vote of thanks was passed to the chairman and directors.

The Chairman, in reply, assured the shareholders that the directors would do all in their power to merit their confidence. He was very sorry that they were not paying a dividend on the Ordinary shares, but the occurrence of that incident more than once had only convinced him of the wisdom of the advice which he gave the shareholders when they first issued the Preference shares, to take their proportion of those shares, as he himself did. He gave that advice, feeling certain that the company would be able to pay the 10 per cent., and all who had taken his advice had had a very fair return for their capital, putting the Preference and Ordinary shares together, notwithstanding the fact that occasionally there had been no dividend on the latter.

Mr. Dyett believed that at the last meeting something was said about their wanting borrowing powers. Had anything been done in the matter?

The Chairman replied in the negative.

A Shareholder observed that as the new cable could not be made without further capital the 10 per cent. Preference shares would, he supposed, be in the same position as the Ordinary shareholders were at present.

Mr. Etlinger replied that the Preference shareholders would then be a step behind those who subscribed the capital for the new cable.

Mr. Dyett assumed that the shareholders would then receive the same advice as was given them before.

The Chairman said he could not tell until the time came. They expected to be able to get the money they wanted at not more than 6 per cent.

A Shareholder: You will not get it.

The Chairman said that they knew they could get it.

Mr. Etlinger: If your £10 Preference shares are standing at £16, surely you can get debentures over them at 6 per cent.

The Chairman repeated that they would have no difficulty in getting as much money as they wanted on debentures at 6 per cent.

The meeting then separated.

MEDITERRANEAN EXTENSION TELEGRAPH COMPANY (LIMITED).

An extraordinary general meeting of this Company was held at the Cannon-street Hotel on the 28th ult., when the subjoined resolutions (which were passed at the extraordinary general meeting of the shareholders on the 3rd ult.) were submitted for confirmation as special resolutions:—"That the Company be wound up voluntarily under the provisions of The Companies Acts, 1862 and 1867"; and "That the Honourable Ashley Ponsonby, a director of the Company, and John George Griffiths, a partner of the firm of Messrs. Deloitte, Dever, Griffiths, and Co., accountants, London, and a shareholder of the Company, be appointed liquidators for the purpose of such winding up, and that the remuneration to be paid to such liquidators shall be left to the decision of the shareholders at a future meeting." The Hon. Ashley Ponsonby presided.

The Secretary (Mr. Edward Tombs) having read the notice convening the meeting, as above,

The Chairman said that the only business before them was the confirmation of the two resolutions mentioned. Before he proposed that, however, he had to inform them that he had received a letter from Lady Carmichael requesting him to convey to the shareholders her sincere thanks for passing a resolution of condolence with her on her severe loss. He then proposed the confirmation of the first resolution.

Mr. Charles Burt seconded the resolution, which was carried unanimously.

The Solicitor of the Company next moved the confirmation of the second resolution.

Mr. Burt seconded the motion.

Mr. Veares said he had attended the meeting with a most complacent mind, but that fact did not shut out the idea of caution. The resolution said that the remuneration of the liquidators was to be settled afterwards, and if he consented to that he did not see how he could refuse whatever demand might be made. He considered an open understanding better than a collision afterwards. He believed that Mr. Griffiths would be very moderate, but his experience of liquidators generally was not assuring. He was a very poor man, and while expecting to lose some money by the company, he did not want to lose any more than he could help. He wanted Mr. Griffiths to say that he would do his best, so that the shareholders might not find themselves cast on a desert shore. He believed that his remarks applied to the chairman as well.

The Chairman: I am co-liquidator.

The Solicitor asked in what way the matter could be left better than at present? It was in the hands of the shareholders, who would pay what they chose, and not what the liquidators might think they were entitled to.

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Mr. BURT said he rather favoured the view of Mr. Veares—that it was a little unsafe to put themselves in the hands of a liquidator without some arrangement, and it would not have been satisfactory to leave the liquidators to take what they thought fit. As to mentioning any specific amount, however, no one could tell what work would have to be done. Difficulties might arise, and if there should be a great deal of work, the shareholders must recognise the fact; but if everything went off easily, the remuneration of the liquidators would be small. He held that the resolution as it stood was a just one to the shareholders, and that they would be safe in leaving it as it was.

The CHAIRMAN said that the reason why he suggested the form in which the resolution stood was that the matter should be left to the shareholders to see what work was done, and when the work was finished. There was some possibility of trouble. There might be litigation, though he hoped not. The amount voted to the liquidators would come from the shareholders.

The SOLICITOR put the resolution, and declared it carried unanimously.

Mr. VEARES then moved a vote of thanks to the chairman, who, he thought, had done his best under the unfortunate circumstances of the loss of the other directors.

The motion having been seconded and carried,

The CHAIRMAN returned thanks, observing that from that day he should cease to be a director of the Company, and become a liquidator. He hoped they would be able to give the shareholders some satisfactory return of a portion of their money when the time came to receive it from the Eastern Company.

Mr. VEARES asked if there was anything looming in the future that looked like *couleur de rose*—the one faint streak which Elijah saw?

The CHAIRMAN replied that the liquidators would do their best for the shareholders, and he believed they would get something. They would be called together again.

The meeting then separated.

THE SWAN UNITED ELECTRIC LIGHT COMPANY (LIMITED).

An extraordinary general meeting of this Company was held at the Terminus Hotel, Cannon-street, on the 2nd inst., "for the purposes of considering and, if approved, of adopting and confirming the terms of an agreement about to be entered into and to be made between the Edison Electric Light Company (Limited), of the first part, the Swan United Electric Light Company (Limited), of the second part, and a trustee for and on behalf of a company intended to be registered under the name of the Edison and Swan United Electric Light Company (Limited), of the third part, being a conditional agreement for the sale, to the last-mentioned company, of certain of the business, goodwill, patents, rights, privileges, and other property of the Swan United Electric Light Company (Limited), and of empowering the directors to do all such things as may be necessary for carrying such agreement into effect, with such modifications and additions (if any) as they may find necessary." Mr. James Staats Forbes presided.

The SECRETARY (Mr. James H. Ivory) having read the notice convening the meeting, as above,

The CHAIRMAN said that those shareholders who attended the first meeting of the Company would remember that when the directors suggested the possibility and the wisdom of bringing together diverse interests in this new and somewhat difficult enterprise, there was a very general concurrence of feeling on the part of the shareholders as to the wisdom of that course, and that almost unanimous expression of opinion sunk in the minds of the directors, and they had steadily kept it in view. The enterprise was so essentially new that it presented no uncommon difficulties, and those difficulties would not be diminished by conflicting interests, and particularly by conflicting interests manifested between those particular inventors or inventions which, in public opinion, seemed at all events to stand in the forefront of this great invention. He did not know which one ought to take off one's cap to first, the Edison or the Swan, but he thought that every one would agree that those were two names which would be much more powerful in association than in competition. A great many things, however, had to be settled before it appeared politic to move far in the direction of amalgamation. They had especially to consider what the effect of legislation was to be, and he thought that both companies had adopted a reasonable and prudent course in waiting to see what the tenure would be upon which they would proceed under Acts of Parliament or provisional orders. Happily they had now arrived at that stage. Whether it was for good or evil only time could develop; but what they knew was that they had some indication of the ground they were treading upon, and they had come to the conclusion that they could now safely proceed to unite these two companies. He hoped that the wisdom of the principle of fusing two interests like Swan and Edison would be admitted without much discussion. They had heard of the old phrase about not buying a pig in a poke, but in such a business as that in which they were engaged they had rather to act contrary to the advice of that old-world wisdom. The Swan Company and the Edison Company had paid considerable sums of money for their patents, &c., and in both cases the vendors had done what vendors always did—they took the money, but they declined to guarantee the validity of the patents, and in fact there was no patent the validity of which could be guaranteed; because patents the moment they turned out to be of great public import were sure to be challenged, and they could only be established after costly litigation. The Swan Company bought the Swan patents, the Edison Company bought the Edison patents, and each of course at once proceeded to prove that he was "the real Simon Pure," and that the other was nothing. And what had rather assisted this amalgamation was the fact that they were drifting in that position. The Swan patents were being challenged by Mr. Edison or the Edison Company, and the Edison patents were being challenged by Mr. Swan or the Swan Company, and they were on the eve, and in fact proceeding some distance with the preliminary measure, each to assert and if he could establish his rights. Well, they all knew what the Patent Laws were. Some shareholders in electric lighting companies had had some experience in the matter in a somewhat analogous subject—the telephone companies. They were, in fact, following the lead of the telephone companies; and they had this one advantage over the telephone companies—that while the latter were absolutely in the dark they in these two companies had the light of their experience. The only difference in the case of the telephone companies was, that the fusion of interests was between Bell and Edison, instead of Swan and Edison. Eventually, after a good deal of threatening litigation and the expenditure of money and the waste of time, the telephone companies did what they proposed to do in these two companies before wasting time or spending money—they came to terms. Having come to terms, they had had a good deal of trouble in beating off infringers, and they had been successful; whereas, if they had been disunited instead of united, and the question had been raised as between themselves, he was not sure that their position would be as safe and as impregnable as it was thought to be now. What had been done in the case of the telephone companies was proposed now to be done with the Swan and Edison Electric Light Companies. With regard to terms, it was of no use crying over spilt milk, if it was spilt—it was of no use raising the question whether the Edison or the Swan Company had paid too much for their patents. They had paid for them, and they had paid on the ground that one must tread in all such cases. A good deal had to be taken for granted when they bought a patent, and after buying a patent one had to go through a certain process of teaching the world, and they could not teach the world without a great deal of expense. In the case of both companies they had spent very much money in bringing the thing where it was. In considering the terms, they had taken the expenditure upon their patents up to the present time as the price at which the companies were to be fused into one common pot. Either of them might have made a bad bargain, but, as between themselves at all events, the bargain was perfectly clear. The Edison Company had Mr. Edison's patent, and his name, and this Company had the Swan patent with his name. It was now proposed that the British business of the Edison Company should be fused with the British business of the Swan Company. There was this difference between them—that the Swan Company had, over and above their British business, paid a considerable price for foreign and colonial patents, and inasmuch as the Edison Company had no similar business or asset to bring into the common pot, they in the Swan Company had reserved to themselves their rights as regarded their foreign and colonial patents, and that was a fact which must be borne in mind when he placed the figures before them. Eliminating from their books the purchase price of the foreign and colonial patents, and the amount of money they had spent on advertising and conducting them so far, they had spent £183,847 in the Swan Company, and they found that the Edison Company had spent £100,000. But he must explain another difference between the Swan Company and the Edison Company, in order that they might understand how the figure of £100,000 would be swollen to £125,000. This Company's purchase of the Swan patents was out and out; the purchase of the Edison patents was a deferred interest to Mr. Edison—a per centage of profits. After the £100,000 had been covered by 5 per cent., the Company and Mr. Edison were to participate in the surplus half and half. They found that they could deal with the Edison Company as a company, but Mr. Edison himself was in possession of a distinct right to do a particular thing, and Mr. Edison had elected to exercise his right, which was, instead of taking cash for his half shares (his deferred interest) to take shares under his contract with the original Company. After a good deal of discussion, the directors came to the conclusion that they had better get the half share of future profits over five per cent. attaching to the Edison Company, as distinguished from Mr. Edison himself, out of the way by a payment of £25,000 in shares. Mr. Edison had elected to remain where he was. His position was this. He was entitled to a B share bearing deferred interest—one B share for every two Edison shares; and what they had done was this. Mr. Edison's was a great name, and no doubt he was a great inventor, and he had bound himself in virtue of this bargain to give them not only the benefit of all that he had discovered, but all that his exceedingly ingenious mind might discover; and he had a very large deferred interest in the undertakings if combined, or in the separate undertaking if the two remained separate, and he supposed that they might speculate so far on human nature as to believe that a man whose reputation as an inventor was identified with a great discovery would have a longing attachment to it, and would do his best to improve it, and that that feeling would not be weakened by the fact that he had a very large financial interest in the matter. They proposed to fuse the companies, making over all the Swan Company had got, excepting their foreign patents, for £183,847, which was what the British business had cost them up to the 30th June, and the Edison Company would put everything they had got into the common pot, including their half share of the contingent profits under the agreement with Mr. Edison, for £125,000. They might increase that capital as much as the necessities of their business required from time to time, but for every £100 of that capital, as it was to exist under the fusion, or as it would exist when increased from time to time, according to the necessities of the business, Mr. Edison would take B shares—for every £75 of the Company's Mr. Edison would get £25 in the nature of a deferred share. The modification they had made was this. Whereas in his agreement with the Edison Company Mr. Edison got one share for every two shares, and the interest on that share was deferred only till 5 per cent. profit was paid on what, for convenience sake, he would call the A shares, they had said that under this new agreement all they could give to him was a fourth and not a half; and further, that the shares so transferred to Mr. Edison were only to bear interest after 7 per cent. had been paid to the A shares. In return for this, Mr. Edison was paid for his contingent interest in the Edison Company, and the new United Company would have the benefit of his services and inventions for a certain period [A voice: Five years]. Every one knew as much as he did about the electric light, and really very little was known. Whatever was in it had to be proved. Certain modifications might be required in the agreement, but they would only be of a small nature, and would not affect the principle of it. But it would be necessary to ask the shareholders to approve the agreement subject to such modifications. The agreement was between the Edison Company, the Swan Company, and a certain George Black, who was the agent of a company about to be registered under the name of The Edison and Swan United Electric Light Company (Limited). There was some sentimental feeling as to whose name should stand first in the title of the new company, and the Edison Company and Mr. Edison rather made a

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point of it that the latter's name should stand first. It was a subject of amicable discussion, and Mr. Swan did not appear to attach such immense value to the question as to break up a bargain so advantageous unless he could have his name first in the title. Again, too, the letters of the alphabet would justify Mr. Edison's name standing first, and so the vanity of the Swan Company was saved in that way. He was very glad to say that every one was satisfied as to this matter, especially the two distinguished inventors. He then referred to the memorandum of agreement, and stated that under it the Edison Company was to sell to the United Company all their business, goodwill, patents, rights, privileges, &c., and the Swan Company would do the same, barring their foreign and colonial patents. The sale was to take effect as from the 30th June last. For obvious reasons, a date was fixed upon as to when the agreement should take effect, if the shareholders approved of it. The United Company would allot to the Edison Company 45,000 Ordinary, or A shares, of £5 each, part of the original capital of the United Company. Forty thousand of those shares would be issued as shares upon which £2 10s. each had been paid: the remaining 5,000 shares would be issued as fully paid, the latter representing the deferred interest of the Edison Company in the half profits over 5 per cent. That was £25,000, and the 40,000 shares, with £2 10s. each paid, made £100,000, so that the two together made £125,000. The reason why it was done in that way was, that at present the subscribed capital of both the Edison and the Swan Companies was half paid up, and in the fusion they would retain the uncalled capital in both companies. With respect, however, to the 5,000 fully paid up shares, they might exercise the option of taking those as half shares with £2 10s. liability on each. They would understand that what they had to do was to broaden the base of the Company, and to have such reserves of credit as would enable them to raise money to carry out the work in the future. They had spent so much up to the present time, and that was all gone. What they had before them was to raise money to carry out the work of the future, and in both companies the unpaid capital would be carried over into the fusion. The B shares represented in the Edison Company Mr. Edison's contingent value, and he would receive one fully paid up B share for every £15 paid up, or credited as paid up, in the United Company, his B shares being entitled to receive a dividend only after the payment of a dividend on the A shares of a sum equal in the aggregate to a preferential cumulative dividend of 7 per cent. The voting power was in this way—one vote for every A share, and one vote for every two B shares, and in a winding up, assuming such a catastrophe before them, the A shares would be satisfied before the B's got anything. As to the Swan Company, they would receive £183,847, and they would take part of that in £2 10s. shares, and part in fully paid up shares. Those who were familiar with the Swan Company would remember that part of the purchase money of the patents was in fully paid up shares which had certain rights, and, in fact, they were entitled to go into the new pot exactly on the same conditions—as fully paid up £5 shares. But with these shares also they gave the option of converting them into half shares if the holders chose, and it was very much to the interest of the new company that they should do so, because a man who took two shares with a call of £5 on them would be broadening the base of the Company, and there was some inducement for them to consent to the conversion (as he proceeded to show) in the way of dividend. Clause 6 provided for having powers hereafter to issue shares either as part of the original capital of the Company, or, as increased capital, as preferential, guaranteed, or deferred shares. Assuming that they had a business in the future securing them 7, 8, or 10 per cent., and there was room for development, they might prefer, as they were established and getting a large annual profit, to raise preferential capital which they would be able to employ as profitably as the orignal capital, but for which they would pay a rate of interest much lower, so that the original founders of the Company would derive the increased benefit. For this reason this power was taken. It was provided that the purchase was to be completed by the 31st October. The United Company was to indemnify and keep harmless the Edison Company and the Swan Company from everything that had taken place. It was provided that they must pass a resolution for confirming the agreement at meetings of the two companies on the 2nd October (that day), and if they refused to do that before the 31st October, the bargain was off. Neither the Edison nor the Swan Company was to be deemed to warrant the validity of any patents sold. That was the usual thing. It was also provided that Mr. George Black was to incur no liability. To sum up, the question was—would they adopt the thing in principle? and adopting it in principle, would they confirm those terms of agreement? Speaking for his codirectors, who had given a great deal of time to it, assisted by the able advice of Mr. Crisp and every one interested in the matter—Mr. Crompton, Mr. Swan, and the directors—they had come to the conclusion that it was a very wise thing to do; and they had also come to the conclusion that in the terms of the agreement they had perfectly secured their bargain. They believed it to be reasonable and just to both sides, and there had been no attempt on the one side or the other to do what was called "catch a passing advantage." They had dealt in a comprehensive and liberal spirit with each other, as they believed a bargain based on that ground was the only kind of bargain likely to be durable. He concluded by moving the resolution contained in the notice calling the meeting.

General TREVOR seconded the motion.

Mr. ROOK asked how the shareholders in the Swan Company would stand after the amalgamation as regarded the foreign and colonial patents.

Mr. BLADON also asked a question on the same point.

The CHAIRMAN, in reply, said that nothing could be more pertinent than the question asked. As regarded the portion of the business of the Swan Company which was represented in the British patents, that would merge into the new company, and the position of a holder of the shares would be that he would receive in respect of a portion of his holding shares in the new company, and he would retain in respect of the foreign business of the company shares in the existing Company. One rung of the ladder at a time was about as much as he or the Board could manage, and when the amalgamation business was out of the way they would have to consider what was to be done with the foreign patents. They must keep the Company alive in some shape or another for carrying on that business. It was a separate business of some importance, and would involve a good deal of generalship to make the most of it. A portion of their existing investment in the shares of the Swan Company they would hold in shares of the new company, and a further portion in shares of the old company, the old share representing in fact the asset of the foreign business. The proportions were about sixty of the new, and forty of the old. They would have to consider very carefully by and by what was to be done with the foreign business. The foreign Edison Company were doing a very useful work for this Company, as they were pioneering all over Europe, and spending a good deal of money in that way, and they were proclaiming their exclusive rights abroad. But the Swan Company were doing abroad exactly what they had done here. They were challenging the pretensions of the foreign Edison Company, and he had no hesitation in predicting that what was taking place now as regarded the British business, would at some date, probably not very distant, take place in reference to the foreign business, because it was perfectly obvious that the very same arguments which made it politic and wise to do what was proposed in this country applied, and even with more force, to the foreign business. However, sufficient for the day was the good thereof. If the shareholders approved the arrangement before them he thought they would have done the best thing they had done since the Company was started, and have laid the foundation of what he was convinced would be a prosperous business.

Mr. JACKSON asked whether the chairman could state that any profitable business had so far been done by either company, or was there anything in prospective—was there any real asset in either of the concerns?

The CHAIRMAN said he was not in a position to say whether there had been any profit. He was not going to hold out that there had been any very great profit. He had tried rather to put this matter in what he might call a judicial form, by saying that they had paid a great deal of money for their patents, for installations, advertising, &c., and he for one, having some interest in the matter, would be very well satisfied if, when they struck a balance on the 30th of June, they found that their capital was intact. He thought that there would not be a bad outcrop [applause]. He did not himself believe that any of the experimental installations had been very profitable, and he was not surprised at it, looking at the nature of the business, and the conditions on which it had been carried out, and to the fact that the wisest people connected with electric lighting had had a vast deal to learn, and he thought that they had a good deal more to learn. Having regard to the enormous advantages of electric lighting, he did not think that they would be called upon to give those advantages away. He could not, moreover, believe that the public would grudge paying a reasonable price for the benefits of the electric light, and a reasonable price, of course, included a fair profit. He might say that they were now beginning to feel their feet. He did not think that they would enter into many contracts unless they saw that they would pay. He thought the thing had now arrived at the threshold of a great future, and they must carefully see that they did not enter into contracts unless they were of a profitable nature. The chairman then put the motion in the usual way, and said he was glad to announce, and he trusted it was a good augury, that the resolution had been carried unanimously.

On the motion of Mr. BLADON, a hearty vote of thanks was passed to the chairman and directors, Mr. Bladon commending the chairman for the careful and lucid explanatory statement which he had made.

The CHAIRMAN expressed his acknowledgments on the part of his colleagues and himself, and stated that there was no doubt they had a difficult task before them, inasmuch as they had to deal with a problem of enormous magnitude, and one of very great difficulty and subtlety. The shareholders might rely, however, that the directors would do their best to promote the interests of all connected with the enterprise.

The meeting then closed.

EDISON ELECTRIC LIGHT COMPANY (LIMITED).

An extraordinary general meeting of the shareholders in this Company was also held on the 2nd inst. at the City Terminus Hotel, to consider the agreement with the Swan Company. We are, however, unable to furnish our readers with a report of the proceedings, as our reporter, in common with the other representatives of the Press, was refused admission to the meeting. We understand that Mr. Stewart presided, and that the agreement was approved.

THE BRUSH ELECTRIC LIGHT AND POWER COMPANY OF SCOTLAND (LIMITED).

The second ordinary general meeting of shareholders was held at Dashwood House, Old Broad-street, on Friday, September 28th, the Chairman of the Company (the Right Hon. the Earl of Crawford and Balcarres) presiding.

The notice calling the meeting was read by Mr. F. M. BROCKLEBANK, the secretary. The report and accounts were taken as read.

The CHAIRMAN said: Gentlemen, the last time I and the directors had the honour of appearing before you we had desired to carry out certain arrangements which we believed at the time were in the interests of the Company. However, it occurred, as no doubt many of you will recollect, that there were certain members of the Company who objected to the scheme, and who spoke to us afterwards, and also at the time, and the consequence was that although we had at the moment been advised that we were acting within our powers, and although we thought it would be for the general interests of the Company, still it was considered desirable that we should take further opinion, which we did. We were then informed that, although we were desirous of carrying out a matter which was within our power, still there might have been objections taken to it; and, consequently, it was considered desirable that we should drop the matter, which you were subsequently informed we had done. Gentlemen, the circular which you have had placed before you to-day has been the result of very careful consideration as to what was the best course to be taken in the interests of the Company. I think, gentlemen, I may claim for your Board that they have done their duty towards their shareholders, and have exercised the most careful supervision which was possible under most

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difficult and trying circumstances [hear, hear]. We have kept all the money which we possibly could, and we have utilised that which we have, although not as we might possibly have desired, in getting large contracts and putting up works. That money, however, has not been thrown away and employed uselessly, and what we have in hand we have placed in a manner which is not imprudent. We have had, as you are aware, very great difficulties in Scotland, as the report tells you, from the excellence of the gas, and the not caring of the citizens of that country to displace it by electric lighting; but above all I cannot help saying that the greatest difficulty we have had has been from our own Government; and the way in which electric lighting generally has been treated, to my mind, is not at all encouraging to any one who desires to bring in a new branch of industry or the working of capital in this country. I am sorry to say anything of such a nature of our Government, but I really think it is driving persons who wish to do good for the country, and at the same time to benefit themselves, into other countries [hear, hear]. We hope the resolution to be brought before you will be accepted, because we consider it is by far the best thing which can be done for the shareholders. Of course, if you refuse to pass the resolution, we can go on; we can shut up the office in London and have a small room, and we can carry on things by the sale of dynamos here and there in Scotland; but we do not really think under the present state of things we could do a paying business, and therefore the wish of the directors has been to place the subject freely and frankly before you. What I have now to request is that the report of the directors and the balance-sheet be accepted by the meeting generally. Perhaps also I might ask Mr. Dickson, our managing director, to be kind enough to state to the meeting his views.

Mr. Thos. Dickson, managing director, said the noble chairman had given a concise statement of the affairs of the Company as far as lay upon the outward surface; but possibly the shareholders would like to hear something which would better the position of the figures, and show to what extent the ultimate thing which they all looked to—namely, the division of the assets—could be bettered. The view which the noble chairman had expressed was the unanimous view of all the directors. Looking at the difficulties before electric lighting, and especially of electric lighting in Scotland, and constituted as this Company was with its peculiarity of shares, and peculiarity of patents, and peculiarity of customers, the Board had come to the conclusion that the best thing to do was to wind up the Company [hear, hear]. The gas companies were very strongly represented on Town Councils, and those gentlemen, although they said they liked progress and that sort of thing, yet they also liked to have in their pockets their share of the interest which they had in gas companies. The two things coming against each other, and backed as it was by the action of the Legislature, rendered it extremely difficult for the Company, in spite of all the efforts of the directors, to make any progress whatever. The directors had stated in the report what they had tried to do; but they were received in such an unfriendly spirit by the Town Councils with whom they tried to open up negotiations, that they found there was no hope of the Company progressing; in fact, all the Town Councils seemed to be combined together, and put their affairs in the hands of one acute electrician and philosopher, Mr. Fleeming Jenkin, to advise them; and the advice which that gentleman gave them would be simply the ruination of electric lighting companies, to the great satisfaction of the Town Council people, who would get the plant for nothing, after getting all the benefit they could out of it. With this view in their minds, the directors waited to see how they could better the Company in the position in which it then was. He went, in the first instance, to see what he could do with the parent company, the Anglo-American Brush Company, and he must say that they received him, as they always had done, with great courtesy. He had no complaint whatever to make of the Brush Company, or of anything which had passed with them; on the contrary, the parent company saw the difficulty. The Company held a large number of £5 founders' shares, and also a sum of money. As regarded the sum of money, he was afraid he must speak about that as last winter's snow—it had gone. But with regard to the £5 shares, over 2,000 in number, he asked the parent company to take back their patents and cancel those shares. That was the short and long of what he proposed. They said they would give so and so; but he said, "You must give us all; you must do the generous thing, and take back the patents for what you have got." After considerable negotiation, which went on in a friendly spirit, it resulted in the agreement that if this Company went into liquidation at once, the parent company would cancel the 2,850 shares, and take back their patents, and the 2,850 shares so cancelled would, in billiard parlance, make the pool for the shareholders so much the better [hear, hear]. But then they had to come face to face with certain other people; the rest of the shareholders had to be seen to. He did not go and negotiate with the £2 10s. men, as they were fellow partners in the concern. He went on the Roman proverb of the "greatest good for the greatest number." Whatever he did for the £5 shareholders would result in benefit to the £2 10s. shareholders. Well, with the residue of the £5 shareholders he had to see what could be done. He got a meeting of the parties; but he experienced great difficulty from the opposition he met with from the promoters of the Company originally, who were themselves in liquidation, and from another party, also a large shareholder, Mr. Hope, who had also since gone into liquidation. It was a difficult job, and he afterwards found that the greater portion of those shares had fallen into the hands of gentlemen who were not easy to deal with; but he saw one gentleman, and in the negotiation with that gentleman received as much courtesy as from the Anglo-American Brush Company, and seeing the difficulty which the Company was under, and that in all probability the meeting would result in nothing, that gentleman fell into the proposal which he (Mr. Dickson) made of doing a simple rule of proportion—viz., 10s. for £2 10s., and £1 for £5; and that equalised the thing in a better and different way to what would be the case if those parties had dwelt upon an obstructive policy, and prevented the shareholders doing what they now wished to do, namely, to voluntarily liquidate the Company upon what would be an equitable basis for the two classes of the shareholders. He might mention that with the report and accounts the directors had also sent out proxies in order to enable shareholders, many of whom were absent from London at this time of the year, to record their votes, and in reply the directors had received proxies amounting to nearly 12,000 shares, and he had notes in his hand from other gentlemen which showed the feeling in favour of the course now proposed. Having mentioned the names of two or three other considerable shareholders who had signified their assent to the proposal, he went on to say that this left but very few £5 shares to come into this arrangement, and he could not doubt that those gentlemen, as colleagues and partners in the concern, would fall into the directors' views, after hearing an explanation, and take their share of the money which was left over. Those gentlemen had asked him several times: "Will not the Company give me so much money for the shares?" and they would be agreeably surprised that the result would be as good and more than they had asked to sell their shares for. Having given this financial information, he had little more to add. The directors had done their best in the peculiar and difficult state of matters; the directors were all electric men, but they did not go electric mad, and they saved the shareholders' money. Having placed the matter as concisely as he could before the shareholders, he left it in their hands; but before he sat down he had one more remark to make. The shareholders would naturally say: "You have disposed of one portion of the assets, but how about the balance of the assets?" Well, he had not been idle with respect to them. The plant which he had put up he had got good value for. It was well put up, and he was in negotiation with a good railway company, who had stated their intention of dealing clearly and fairly with regard to the plant. He had negotiations in hand for the sale of the plant conditionally, which would leave the Company without the loss which would otherwise be the case. This, with other matters, would give even a better look out than the statement presented to them to-day.

The Hon. A. Ponsonby: You might say that the machinery at the railway station has answered extremely well, and has saved many lives.

Mr. Dickson: With regard to the plant we have put up at the station, it has given satisfaction to a very considerable extent there; and I think, from the negotiations I have entered into with the directors and secretary, I shall have no difficulty in getting it taken off our hands at a very fair rate indeed. Any one who noticed the report of the North British Railway Company the other day will have observed that from the inception of this Company there have been fewer accidents on the North British than before; and the traffic manager has said that he goes to bed with the sure conviction that the men are not groping about in the dark, but that our lights were shining clear and bright.

Mr. Walker said he thought the best course to be adopted was that recommended by the directors. As the vendors seemed to have met the shareholders in a fair spirit by relinquishing certain claims he thought there should be a reduction in other matters. He was dissatisfied with the legal expenses. The legal charges seemed to be enormous, and, at the same time, the directors seemed to have been very badly advised. Were the shareholders to pay for bad advice and bad law? There was another matter he would refer to. This had been a disastrous concern. He had paid as much as £3 premium for some of his shares; and seeing that under the proposed arrangement the shareholders would only get 20s. or 30s. per share returned, he thought it would show a proper feeling on the part of the directors if they would forego some of their fees, which were charged at £1,537 12s. 1d. Then there were the administrative expenses; could there not be a reduction made there?

Mr. Peter Cunningham said that at the last meeting he was told by the solicitor that the directors had taken some measures to get the Anglo-American Brush Company to make some reduction on account of some mistake in the prospectus, they not having the exclusive right to the incandescent light. He would ask whether those measures were successful?

Mr. Dickson said that the directors took the best advice, and found that they could not go against the company, who stated that they had kept within the law, and therefore it would have been a waste of money to do what Mr. Cunningham referred to.

Mr. Cunningham asked whether the vendors were entitled to sell their shares?

Mr. Dickson: Certainly.

Mr. Cunningham said that on one occasion, at a meeting, it was stated that this Company only paid £15,000 in cash; but if those vendors' shares had been sold, and spread over the country, and came in for a *pro rata* amount of the divisible assets, it would make a considerable difference in the amount which would otherwise be returned to the other shareholders.

Mr. Walker: The unfortunate thing is that those shares were not tied up for a time.

The Chairman: I do not think you could have done that.

Mr. Dickson: At that time they were masters of the situation, and every one was running after the shares, and some paid a premium for the £5 shares and the others.

A Shareholder: Have we the same solicitor now as we had some time ago?

Mr. Dickson: No; our present solicitor is Mr. Harold Browne, of Messrs. Linklater and Co.

Mr. Walker: Has the late solicitor resigned?

Mr. Dickson: We have appointed Messrs. Linklater and Co., and the other gentleman has retired. As regarded the directors' fees, he (the speaker) would never work a similar thing for twice or three times the amount which he had received for working this Company. There was one further crumb of comfort he could give the shareholders, and that was that in the event of the parent company taking up the Dundee Provisional Order he expected that company would pay to this Company a fair *pro rata* sum of the amount which this Company had expended in obtaining that order.

Mr. Cunningham said he really thought the amount charged for directors' fees was not excessive [cheers]. He sympathised with the directors in the position they were in. It was not right for men to work without some return, and in this case the amount charged for directors' fees only came to about 1s. 6d. per share.

The Hon. A. Ponsonby said that when the Company was started no one could have foreseen that a Liberal Government, with Mr. Chamberlain as a member, would have thrown the trammels they did over the electric light, and also shown the opposition they did to anything like new suggestions. The recent legislation was stringent against everything except the gas companies, and one might think it was drawn up by gas people. When the electric light first came out it sent down the price of gas shares, and the chairman of one gas company said, "We can settle all that," and they had settled it. If electric lighting had been fairly and properly treated, this Company would have been a flourishing company, and he thought that the directors might take credit for saving so much as they had done [hear].

Mr. F. W. Reynolds expressed the hope that it might not go forth that

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the Company was winding up in consequence of that Act. He had no doubt there was no better dynamo than the new Brush dynamo; there were 30,000 of such lights in America, and the American people were no fools. They had adopted the Brush dynamo, and therefore he thought it was a pity it should be supposed that it was not a success simply because they did not want the light in Scotland. He suggested whether it would not be possible to go on another year, the directors pledging themselves to make no further calls, and limiting the expenses [No, no].

A SHAREHOLDER: Wind up and get the money.

A SHAREHOLDER asked for an explanation of the item of £1,944 for sundry charges.

The CHAIRMAN said that about £1,500 of that was an estimate for parliamentary charges, which could not be foreseen, as there was no legislation on the subject when the Company started.

Mr. W. LADD, referring to the £25,000 paid by this Company for patents, said he wished the shareholders to understand that not one half of that sum of money went to the parent Brush Company. With regard to the suggestion of Mr. Reynolds, he wished to say that the directors had tried all they could to do electric lighting in Scotland. No one had more faith in electric lighting than himself, and no one had more faith in the Brush machinery; he believed it to be the best dynamo machine in existence, and would last long after others had died out. Then came the question, how was it that the Company had not succeeded? He believed it was absolutely on account of the Act of Parliament which was passed [hear, hear]. He had come reluctantly to that conclusion; and when the whole position came before the Board for discussion, he, looking at this difficulty, and also the stern difficulties thrown in the way, came to the conclusion that it was impossible to carry on electric lighting in Scotland at a profit.

Mr. REYNOLDS: At present?

Mr. LADD: At present; but when you say "at present," I would ask when will it be altered [hear, hear]? What prospect have you of this being altered for several years? In the meantime your capital must diminish if you go on, and then we shall have no capital to do the lighting with. It does occur to me that the course proposed is the best one to pursue.

The CHAIRMAN said he would now formally propose that the directors' report and the balance-sheet be adopted.

Mr. CUNNINGHAM seconded the motion.

Mr. WALKER: I shall move an amendment, unless you signify your intention to meet us in regard to the directors' fees.

The CHAIRMAN: I shall be glad to return every penny I have received [No, no].

Mr. CUNNINGHAM: It should be left to the Board.

Mr. WALKER: Is it unreasonable to ask what is the amount to be paid to the late solicitor, and have his costs been taxed, or has he received the whole of his claim without taxing?

Mr. DICKSON: I will do my best to see that he shall not receive one farthing more than we can keep him from getting.

Mr. WALKER: I take it from that that you are dissatisfied?

Mr. DICKSON: The amount is unpaid, and you may give me credit that it shall be looked narrowly into and taxed in every way possible to get it reduced.

Mr. WALKER agreed that the best thing to do was to wind up the Company as quickly as possible, but he would take the sense of the meeting whether the directors ought not to make some concession to the shareholders in regard to their fees. He moved that the directors be requested to reduce their fees by one half.

A SHAREHOLDER said he should be sorry if any one seconded that [hear, hear]. The directors had shown that they had employed the money as carefully and successfully as they could, and the shareholders might feel thankful that there would be so much to return as they were led to expect.

A SHAREHOLDER said he agreed with the last speaker.

The motion of Mr. Walker was not seconded.

The resolution for the adoption of the report and accounts was then put and carried unanimously.

The meeting then resolved itself into an extraordinary general meeting, and the Chairman formally proposed:—"That the Company be wound up voluntarily under the provisions of the Companies' Acts, 1862 and 1867."

Mr. WALKER seconded the motion.

A SHAREHOLDER asked whether it was not possible for this Company to keep the concession for Scotland in its own hands?

The CHAIRMAN: You could not if you liquidate.

The SHAREHOLDER: Is there any chance of the parent company starting another company on the ruins of this? Perhaps Mr. Ladd will tell us.

Mr. LADD: As a director of that company, I have not even heard a hint of such a thing.

The Hon. Mr. PONSONBY: The matter came before us and we thought it over, namely, whether we could not get rid of all the *employés* except the secretary, and take a very small office, and rest upon our oars for a year; but, on the whole, it was deemed better, as we had a large sum of money, to let the shareholders have the advantage of it.

The motion was put and carried unanimously.

The CHAIRMAN then moved:—"That the vice-chairman, Mr. Robert Ewing, and Mr. Thomas Dickson, be, and are hereby nominated liquidators, for the purpose of such winding-up, and that the remuneration of the liquidators be fixed by the shareholders."

Mr. CUNNINGHAM seconded the motion.

Mr. WALKER suggested that a shareholder should be associated with the liquidators named, and also that the liquidators' remuneration should be fixed by the present meeting.

Neither suggestion was adopted by the meeting, the general feeling being that the amount of remuneration should be voted when the liquidation is finished.

In reply to a question,

Mr. HAROLD BROWNE and Mr. DICKSON both expressed the opinion that the liquidation might be completed in about two months.

The resolution was then put, and carried unanimously.

Mr. HARRINGTON: I move a vote of thanks to the chairman and directors. Our strongest expression of thanks is due to the gentlemen on the other side. They have fought an up-hill game, and they failed, and they have, what few had, the manliness to admit it [hear, hear]. And they call us together to save our money, or some of our money. I trust it will be an example to other companies to go and do likewise.

A shareholder seconded the motion, which was carried, and the chairman having acknowledged the compliment, the meeting broke up.

THE JABLOCHKOFF ELECTRIC LIGHT AND POWER COMPANY (LIMITED).

The ordinary annual general meeting of this Company was held on the 4th inst., but owing to the presure on our space we are obliged to hold over our report of the proceedings until next week.

COMPANIES' SHARE LIST.

TELEGRAPHS.

Companies.	Closing Prices Oct. 3.		Business Done Week Ending Oct. 3. Highest.	Lowest.
Anglo American	46½,	46¾	47⅛	46½
Do. Preferred	78½,	78¾	80	78½
Do. Deferred	16½,	16¾	17	16¼
Brazil Submarine	10¼,	10¾	10 15-16	10½
Cuba	10½,	11	10¾	10½
Do. Preference	17,	18	17	—
Direct Spanish	5¼,	5½	5½	5
Do. Preference	15¾,	16½	—	—
Direct United States Cable	11⅞,	12⅛	12 13-16	12
Eastern Telegraph	10 15-16,	11 1-16	10 15-16	10 11-16
Do. 6 per Cent. Preference	12¾,	13½	13⅛	—
Do. 5 per Cent. Debentures, 1899	103,	107	—	—
Eastern Extension	11 9-16,	11 11-16	11 7-16	11¼
German Union	10,	10½	10 3-16	—
Globe Telegraph and Trust Company	7 9-16,	7 11-16	7 11-16	7½
Do. Preference	12¾,	13	13	12 13-16
Great Northern	12¾,	13	—	—
Indo-European	31,	32	—	—
Mediterranean Extension	1½,	2	—	—
Do. Preference	2,	4	—	—
Reuter's	8¼,	9¼	8¾	—
Submarine	220,	230	221½	—
West India and Panama	¾,	1	⅞	—
Do. 1st Preference	6¼,	6¾	6½	—
Western Brazilian	5⅜,	5⅝	5¾	5 9-16
West. Union 7 per Cent. 1st Mortgage	122,	121	—	—
Do. 6 per Cent. Sterling Bonds	100,	103	—	—

TELEPHONES.

Companies.	Closing Prices Oct. 3.		Highest.	Lowest.
Consol. Telephone and Maintenance	½,	¾	—	—
Oriental	5-16,	7-16	—	—
United Telephone	8½,	8¾	8½	8⅝

ELECTRIC LIGHT.

Companies.	Closing Prices Oct. 3.		Highest.	Lowest.
Anglo-American Brush Lgt. (£7 paid).	2½,	2¾	3⅛	1½
Do. (fully paid)	4½,	5½	4¾	4 3-16
Hammond Light (£3 15s. paid)	1¾,	2¼	2¼	1½
Eastern Electric (£4 paid)	1¾,	1¾	—	—
Swan	1⅞	2⅛	2 1-16	1¾
Maxim-Weston	⅛,	¼	3-16	—

MISCELLANEOUS.

Companies.	Closing Prices Oct. 3.		Highest.	Lowest.
Telegraph Construction	33½,	34	33¾	—
India Rubber, Gutta Percha, and Telegraph Works	29½,	30½	30½	30⅛

TRAFFIC RECEIPTS FOR SEPTEMBER, 1883.

Companies.	Sept., 1883.	Sept., 1882.	Incrse.	Decrs.
Cuba Submarine Company	2,500	2,283	217	—
Direct Spanish Telegraph Company	1,701	1,812	—	111
Eastern Extension Telegraph Company	37,271	32,955	4,316	—

THE EASTERN TELEGRAPH COMPANY (Limited.)

SIX PER CENT. DEBENTURES.

NOTICE is HEREBY GIVEN that all the SIX PER CENT. DEBENTURES of the Company falling due on the 15th October, 1883, being Nos. 1 to 2,320, inclusive, will be PAID off on and after that date by the Bankers of the Company, Messrs. Glyn, Mills, Currie, and Co., 67, Lombard-street, London. The Debentures, with any unpaid Coupons, should be left with Messrs. Glyn and Co. three clear days for examination. Interest on the Debentures will cease from the 15th instant. By order of the Board,

G. DRAPER, Secretary.

Offices, 66, Old Broad-street, London, E.C.,
4th October, 1883.

A STUDENT who has passed his examination in connection with the South Kensington Science Department, in Electricity, would be glad to fill some SITUATION in connection with a branch of the trade. Experienced with workmen in the metal trade.—Address, W. ELLIOTT, Nelson-street, Stroud, Gloucestershire.

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NOTES.

NEW PAPER.—The *Telegraphers' Advocate* has joined the ranks of electric journalism. It is published in New York.

THE SOCIETY OF ELECTRICIANS, PARIS.—The first general meeting of this recently-formed society is fixed for the 15th November.

ELECTRIC LIGHTING IN CALCUTTA.—The grounds of the Calcutta International Exhibition are to be lighted by arc and incandescent lamps.

COUPONS.—The coupons of the Submarine Cables Trust due on the 15th inst. will be paid on and after that date by Messrs. Glyn, Mills, and Co.

ELECTRIC TRAMCARS.—It is stated that the Mission-street Railroad in San Francisco intend to experiment with electrically propelled cars on their line.

TELEPHONE CONVENTION.—The fifth convention of the National Telephone Exchange Association will take place at Cincinnati, U.S., on the 16th instant.

VIENNA ELECTRICAL EXHIBITION.—M. Cochery, the French Minister of Posts and Telegraphs, has left Paris for Vienna, on a visit to the Electrical Exhibition there.

SHIP LIGHTING.—The Swan United Electric Light Company have received an order to fit the "Clan Mathieson," now building at Glasgow, with incandescent lamps.

REMOVAL OF OFFICES.—The offices of the Gülcher Electric Light and Power Company (Limited) have been removed from Battersea Foundry, S.W., to 4, Coleman-street, Bank, E.C.

TRAFFIC RECEIPTS.—The Eastern Telegraph Company's estimated traffic receipts for the month of September, 1883, amounted to £42,778, and to £57,271 in the corresponding period of 1882.

BRUSH SYSTEM IN AMERICA.—It is reported that the Buffalo authorities have entered into a contract with the Brush Company for lighting certain streets at 55 cents per lamp per night.

INDO-EUROPEAN TELEGRAPH COMPANY.—The board of this company have declared an interim dividend for the half year ending June 30th last at the rate of 5 per cent. per annum, free of income-tax.

UNDERGROUND v. OVERHEAD WIRES.—The Newington Vestry are of opinion that "overhead wires ought not to be allowed, and that all telegraph and other wires should be placed underground."

THE DUPLEX COMPANY.—Vice-Chancellor Bacon has appointed Mr. Samuel Lovelock official liquidator of the Duplex Electric Light, Power, and Storage Company, in place of Mr. William Waddell.

LECTURES.—Mr. W. Kinsgland is to deliver two lectures at the Huddersfield Exhibition on the 17th and 31st inst. The titles of these lectures are "The Production of Electricity," and "The Applications of Electricity."

DIRECT UNITED STATES CABLE COMPANY.—This company notify that the half-yearly interest on their six per cent. debenture loan will be paid, on and after the 15th inst., at the Consolidated Bank, Threadneedle-street.

ELECTRIC LIGHTING AT LEEDS.—The Leeds Town Hall has been lighted this week by the Messrs. Crompton and Winfield, of Birmingham, on the occasion of the musical festival. We shall refer to this installation in a future issue.

WEST INDIA AND PANAMA TELEGRAPH COMPANY.—The directors of this company have resolved, after placing £20,000 to reserve, to recommend a dividend of 3s. per share on account of arrears of dividend on the First Preference shares.

DOMESTIC LIGHTING.—Messrs. Crompton and Co. are, we understand, fitting up the house of Mr. Cassell to be lighted with Swan lamps, similar to that of his neighbour, Mr. W. S. Gilbert. The motor to drive the dynamos will be a 6 h-p gas engine.

ELECTRIC LIGHT FOR LIGHTHOUSES.—Since the 1st inst. the old light in the Calais lighthouse has been supplanted by an electric light. It is stated by the authorities that the new light "should be visible in clear weather from a distance of about twenty-four miles."

NEW CABLE BETWEEN SWEDEN AND DENMARK.—The four cored cable manufactured by Henley's Telegraph Works Company for the Swedish and Danish Governments was successfully laid between Elsinore (Denmark) and Helsingborg (Sweden) a few days ago.

THE TELEPHONE AT WINDSOR.—H.R.H. Princess Christian has had a telephone line put up to connect her residence, Cumberland Lodge, with the fire station at Windsor. The line is a little more than four miles long, and is intended only for fire alarm purposes, we believe.

THE TURIN ELECTRICAL EXHIBITION.—The committee of this exhibition inform us that, with a view to facilitate the participation of the present exhibitors at Vienna in the Turin Exhibition, they have postponed the date for sending in applications for space until the 31st instant.

GREAT NORTHERN TELEGRAPH COMPANY.—The traffic receipts of this company for September, 1883, were £23,640. From the 1st January to 30th September, 1883, they amounted to £191,680, against £182,294 in the corresponding months or 1882, and £180,279 for the same period of 1881.

The TELEPHONE IN SOUTH AMERICA.—The exchange that has been established in Rosario by the United Telephone Company of Buenos Ayres, has led to the forming of a private company at Santa Fé. It is proposed to connect Cordoba, Santa Fé, and other intermediate towns with Rosario.

TO BE WOUND UP.—A petition has been presented by Mr. W. R. Crowe for the winding up of the London and Provincial Electric Lighting and Power Generating Company, of Great Winchester-street, E.C. The petition is to be heard before Mr. Justice Chitty, at the Royal Courts of Justice, on the 3rd November.

ELECTRIC LIGHTING IN THE STATES.—The City Council of Evansville, Indiana, has given the local company a five years' contract to light the city with 10 towers of four lamps each, 100ft. high, 14 arches, 50ft. high, across the intersections of streets, each with one lamp, and two masts bearing lights.—*Sanitary Engineer*, New York.

OVERHEAD WIRES IN LONDON.—It is stated on good authority that about 1,400 wires cross Leadenhall-street, which is situate in the busiest part of the city. What this number will have increased to by this time next year we cannot foretell, but there will not be much of the azure sky left to gladden the vision of inhabitants of Leadenhall-street, soon.

COLLIERY LIGHTING.—The contract for the lighting of the new shaft of the Wigan Coal and Iron Company, Wigan, has been secured by the Hammond Electric Light Company through their office at Manchester. The installation will be

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under the charge of Mr. F. D. A. Goold, the electrician to the Hammond Company, who is also at present acting as manager.

Underground Wires. — The Land and Underground Cable Company have agreed with the Commissioners of the District of Columbia, U.S., to put down a section of underground cable for use of the fire alarm service. The wires are put down as an experiment, to be removed if Congress does not agree to use the system. The cost is borne by the company.

The Forth Bridge.—This bridge is to be lighted by electricity. The work has been placed in the hands of Messrs. Crompton and Co., who will furnish the requisite machinery to supply 11 Crompton arc lamps and 120 Swan incandescent lamps. The peculiarity of this installation is that the leads will be rather long and have to be extremely well insulated in order to guard against the action of water.

Electric Lighting at Ilfracombe.—On the occasion of an aquatic entertainment given in the Ilfracombe Swimming Bath a few days since, the proceedings were illuminated by six Brush lamps supplied by the Great Western Electric Light Company. The dynamo supplying the current was driven by a Marshall 14 horse-power engine. The arrangements were carried out by Mr. A. Brown, electrician to the company.

Water Level Indicators.—The new water storage tank, which will hold 230,000 gallons, and has just been erected at Colchester, has been fitted with an electric indicator of the level of its contents. The receiver is placed in the engine room at the pumping works, and denotes every rise or fall of three inches on an indicator. The engineer has therefore no excuse for not knowing how much water he has in his storage tank.

The New Spanish Cables.—The Cadiz shore end of the new cable was successfully landed at Cañuelo del Puento in Cadiz Bay on Wednesday, the 3rd inst., and seven miles paid out to sea. The ss. "Dacia" and "International" sailed for the Canary on the 4th inst. Don Antonia Augustin, representing the Spanish Government, and Mr. T. Y. Buchanan, late of H.M.S. "Challenger," joined the expedition at Cadiz.

Water Pipes Broken by Lightning.—The *Springfield Republican* says that during a thunder storm in Amherst, Mass., U.S., recently several violent flashes of lightning were seen and immediately afterwards water stopped running at several service pipes, and a few minutes later water poured from a shattered water main. Investigation showed that lightning had struck the pipe where the roots of a large tree passed near it.

Testing Electric Lamps.—Efforts are being made to obtain independent and accurate tests of the electric lamps exhibited at the Chicago Railway Exhibition. A committee has been appointed with Dr. Henry Morton at its head, and premises taken in Chicago in which to carry out the tests. It only remains for the electric light companies concerned to subscribe their respective shares of the costs of carrying out the tests for the committee to get to work.

Electric Lighting in Brussels.—On the occasion of the recent visit of the King of Spain to Brussels the Government had the route from the Northern Station to the Palace lighted by Jaspar, Gramme, and Brush arc lamps. The wires were strung on poles put up by some men of the telegraph companies of the army in less than two days. The Gramme and Jaspar lamps were supplied by the Compagnie Générale d'Electricité, and the Brush lamps by the Compagnie Belge et Hollandaise d'Electricité.

Anglo-American Telegraph Company.—At a meeting of the Board of Directors of this company, held on Thursday, 4th instant, it was resolved, after placing the quarterly sum of £37,500 to the renewal fund, to declare an interim dividend for the quarter ending 30th September, 1883, of 15s. per cent. on the Ordinary stock, and 30s. per cent. on the Preferred stock, both free of income-tax, payable on the 1st November to the stockholders registered in the books of the company on the 30th September, 1883.

Another Ship to be Lighted.—Messrs. Woodhouse and Rawson, of Queen Victoria-street, E.C., have obtained the contract for lighting the ss. "Cahors," which has recently been launched by Messrs. John Keys and Sons, of Kirkcaldy. She has been built for Messrs. Howard Smith and Sons, and is intended for the Australian trade. The installation will consist of about 150 Woodhouse and Rawson ten, twenty, and fifty candle-power incandescent lamps. The saloon fittings will be of an elaborate character to harmonise with the style of the furniture and decorations.

The Wire Tying Question.—The dispute between the United and the London and Globe Telephone Companies has at length emerged from the police-court, and the matter is to be settled in the purer, though perhaps more costly, air of the Court of Chancery. On Thursday, the 4th inst., the case against William Goodfellow and James Mollineux, in the employ of the London and Globe Company, who were charged with tying up the wires of the United Company, was concluded. Some good may possibly come of all this unseemly litigation, but it seems to us that the chief people who will benefit by it will be the lawyers.

Brazilian Submarine Telegraph Company.—At the approaching meeting of this company the directors will recommend the declaration of a final dividend of 3s. per share, making, with previous interim payments, 6 per cent. for the year ending June 30 last, carrying forward a balance of £19,434. In view of the necessity for a large expenditure in repairs and duplicating the Madeira-St. Vincent and St. Vincent-Pernambuco sections, which, with the duplicate Lisbon-Madeira section laid last year, will provide a second line throughout the company's system, the directors think it unadvisable to make any distribution of profits on this occasion beyond 6 per cent.

Underground Wires in New York.—Some time since, *vide* p. 293 of our present volume, we printed a circular letter, which had been issued by the General Committee on Underground Communication, formed in New York, containing instructions and hints to inventors, as to the objects at which the committee were aiming. They want inventors to submit plans for laying wires of all kinds underground, in order that they may be able to pronounce upon the best method of so doing. To meet English inventors half way the committee have arranged with Messrs. Woodhouse and Rawson, of Queen Victoria-street, E.C., to receive any communications on this subject on their behalf.

Earthquakes.—Indian papers report that three slight shocks of earthquake were experienced at Bushire on September 8. The direction of the last shock was from east to west, and its duration two seconds. The Paris correspondent of the *Standard*, telegraphing from that city on Tuesday night, says:—"A telegram just received from Algiers states that a strong shock of earthquake was felt at Philippeville at half-past one o'clock this morning. The oscillation was in the direction from north to south. The whole population

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of the town is described as having rushed terror-stricken into the streets. At Jammasses the church and barrack walls were cracked; at Stora a house was also damaged."

A Legend from New York.—"The last rail laid on the Northern Pacific Railroad," says a New York paper, "was attached to a Western Union wire running into the branch office at No. 8, Broad-street, and while President Villard was driving the golden spike, the blows of his silver sledge hammer were repeated in this city on the telegraph instrument. General officers of the road gathered around the instrument, listening to the strokes that told of the completion of a great national highway." This reminds us of the story about the bombardment of Alexandria being heard at Malta by means of a telephone connected to the Alexandria cable—only the latter story did not happen to be in strict accordance with the truth.

Eastern Telegraph Company.—This company notify that all the Six per Cent. Debentures of the company falling due on the 15th October, 1883, being Nos. 1 to 2,320 inclusive, will be paid off on and after that date by the bankers of the company, Messrs. Glyn, Mills, Currie, and Co., 67, Lombard-street, E.C. The debentures, with the unpaid coupons, should be left with Messrs. Glyn and Co. three clear days for examination. Interest on the debentures will cease from the 15th inst. Holders of the above debentures desiring to exchange them for the company's Four per Cent. Debenture Stock now being issued can obtain all information on this subject on application to the secretary of the company, 66, Old Broad-street, E.C.

The Telephone in Cornwall.—On the occasion of the recent Mining Institute Exhibition in Redruth the two halls in which the exhibition was held were placed in direct telephonic communication with the 150-fathom level in Pedn-andrea Mine, which is situated at the head of the town. The work was carried out under the personal superintendence of Mr. T. Scott Anderson, the representative of the United Telephone Company, and that gentleman's assistant was underground in the above mine during both days of the show practically illustrating the value of the telephone in mining operations. The United Telephone Company were granted a silver medal for their general exhibit, as well as two bronze medals for their apparatus.

Electric Lighting at Leeds.—On Thursday, the 4th inst., an exhibition of the electric light was given at the show rooms of Messrs. Marsh, Jones, and Cribb, 48, Bow-lane, Leeds, at which upwards of 200 persons were present by special invitation. These rooms have for some time been fitted with the electric light, the power for running the dynamo being obtained from the ordinary shafting used for driving the tools in the workshops. The electrical plant consists of a 100-light Ferranti dynamo machine, and sixty Swan 20 candle-power lamps, fitted in most cases to the existing gas brackets, and also to one or two special electroliers. Great satisfaction was expressed with the steadiness of the lights. The work has been carried out by Messrs. Kingsland and Smith, the engineers to the Ferranti Company.

The Telephone in Belgium.—By royal decree concessions for the erection of telephone lines in Brussels, Antwerp, Charleroi, Ghent, Louvière, and Verviers have been granted to the Belgian Bell Telephone Company. These concessions include a radius of 10 kilometres, a little over six miles. A concession for the town of Liege has also been granted to the Compagnie Liégeoise du Téléphone Bell. These concessions are for a term of 25 years. The subscription rates are fixed at 250 francs (£10) per annum, and 150 francs (£6) for a half year. Outside a radius of 3 kilometres an additional 50 francs (£2) will be charged for each kilometre or fraction of a kilometre. The administration of the posts and telegraphs reserves to itself the right of organising the telephone service at any time it may think fit, and retains the right of free access to the offices of the companies.

The Telegraphic Service in Spain.—A correspondent of the *Daily News*, telegraphing from Madrid on Saturday last, says:—"I regret to say that this week foreign and Spanish correspondents have again had to complain of the detentions of telegrams in consequence of their being sent from the central office to the Political Censor in the Home Office. This quarantine often entails from five to fifteen hours' delay. There is now no excuse in the state of the land lines or in the Bilbao and Vigo cables, which have been the whole week in perfect order. It should be pointed out at the same time that some telegrams, with more palatable news, though given in later, were allowed to pass first. No redress is possible, as the letter of the Conventions is observed by the fact that the messages are finally forwarded, and reimbursement is eluded, as the treaties only stipulate for it in the case of suppressed messages."

Electric Lighting in the City.—At a meeting of the City Commission of Sewers, on Tuesday last, Mr. Innes asked the solicitor if the fact of tenders for public and private lighting being asked for by the Electric Lighting Committee pre-supposed an engagement with a company before the application for a license or order.—Mr. Baylis, the solicitor, replied in the negative, and various other questions of which Mr. Innes had given notice in the event of an affirmative reply were not put.—Mr. Stoneham brought up a report from the Electric Lighting Committee, submitting proposals from the Edison and Gülcher Companies, and recommending their adoption, subject to sufficient guarantees being furnished by the companies, as the basis of provisional agreements to be entered into with the companies in view of the proposed license to be obtained from the Board of Trade for electric lighting. It was determined to print and circulate the report, and meanwhile to defer its consideration.

Electric Lighting at Pentonville.—The contract between the Maxim-Weston Company and the Clerkenwell Vestry for lighting Pentonville-road has terminated. The contract was almost concluded, when the main cable was found to be defective (the secretary of the company stated that it had been wilfully damaged), and it was not thought advisable to repair it under the circumstances. Gas, therefore, reigns supreme once more on Pentonville-hill. But the vestry have found out that they would like a little more light than is given by the ordinary burners, and consequently new lanterns and burners have been ordered, and will shortly be in place. The cost of these will come to £166, whilst the extra gas required will take £220 per annum. In addition to this the vestry have administered an awakening dig in the ribs to the gas company, and reminded them that they want good measure, and not short. Who says the electric light does no good? It actually increases the prosperity of its rival, and will probably continue to do so, as long as it is supplied on the careless catchpenny system. When, however, the right men are gradually differentiated to the front, we shall have a different story to tell.

A Cool Proceeding.—We take the following from the police news of a daily paper of Thursday:—On Mr. De Rutzen taking his seat on the bench on Wednesday morning, a gentleman, who said he was Mr. John Peet, of Milton

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House, Marlborough-road, St. John's Wood, informed his worship that he wished publicly to complain of the conduct of some persons in the employ of the Telephone Company. He was, he said, a merchant in the City, and, being a widower, left his two daughters in charge of his house during his absence from home. On reaching home on Tuesday evening, the young ladies told him that two men had called, and said they had come to fix some telephone wires on the top of the house. As his daughters were unaware how far the authority of the men extended in such matters, they allowed them to proceed with their work, and when he reached home in the evening he found to his astonishment the wires fixed to his chimney-pots. Neither the Telephone Company nor any one else had ever asked his permission to place the wires in that position; in fact, he had not received any communication on the subject at all. He knew nothing whatever about the matter until he found the wires fixed. At daylight in the morning he went on the roof of the house and cut the wires, so that when the men came to resume their work they found them hanging against the opposite house. His lease was a very peculiar one, containing many important covenants, and if these were infringed by the conduct of the workmen he had referred to, the matter might be very serious to him." Mr. De Rutzen explained that he could not help Mr. Peet, but that no doubt the press would notice it. We hope that the telephone *employés* in this instance were exceeding their orders, if not, we cannot too strongly condemn such high-handed proceedings as these.

Electricity as a Motive Power.—This was the title of a lecture for working men delivered by Professor Ewing in the Hall of Dundee University College, on the evening of Friday, the 15th inst., shortly after the opening ceremony, referred to in another note, had been concluded. The lecturer began by giving it as his opinion that the transmission of power by means of electricity was capable of even greater development than the utilisation of electricity for the production of light. He proceeded to describe the numerous electric motors now in use, and showed by a number of experiments that turnip cutters, winches, emery wheels, circular saws, &c., could be made to revolve by means of electric motors, though the generating machine was some distance off. He instanced the adaptability of electric motors to cases where space was an object. They could also be advantageously used whenever the object to be moved was required to revolve very fast, and against only a slight resistance. As an example, he cited the spindles of a spinning frame, to drive which by the present system of belts from a drum involved an enormous waste of power in overcoming useless friction. In conjunction with Professor Fleeming Jenkin he had patented a plan of turning these, by making each of them a separate armature in a manifold electric motor, whose field magnets would reach completely round the frame. Perhaps the most fertile application of electric energy was to be looked for in the supply of small quantities of power for domestic uses, and for the convenience of small manufacturers. The lecturer also illustrated Professor Fleeming Jenkin's system of telpherage. In conclusion, Professor Ewing alluded to the temporary cloud which had come over electrical matters as a natural effect of the feverish speculation of two years ago. Those who could look below the surface had not lost faith in the wonderful possibilities of this newly developed agent, and he had no hesitation in saying, although at the risk of being accused of advertising his own wares, that any young engineer who neglected to study the industrial application of electricity was barring in his own face the most inviting avenue which the profession now offered.

H.M.S. "Orontes."—In our last issue we stated briefly that the "Orontes" troopship had sailed from Portsmouth, and that she had been fitted out with incandescent lights by the Swan United Electric Light Company. We are now able to add a few details as to the engines used, distribution of lights, &c. The contract was given to the Swan Company on June 13, it being stipulated that the engines should be Gwynne's new high speed compound direct driving engines. The total number of lamps fitted on board and which are to entirely replace every other kind of light is about 385; of these 55 are of 20 candle-power each, and the remainder 12 candle-power each. As the 12 candle-power lamps are made to take the same E.M.F. as the 20 candle-power ones, they can be placed on the same circuit parallel with these latter, an important advantage. The 12 candle-power lamps have only been recently introduced, but the results obtained with them are highly satisfactory. Both kinds of lamps require about 60 volts E.M.F. The majority of the fittings are short serviceable brackets and pendants, but a new form of guard fitting has been used in large numbers. The back is of iron enamelled white, of the shape of a disc about 8in. diameter, and the front is of strong clear plate glass set in a brass rim, hinged at one side and locked at the other, forming a complete protection to the lamp, which can, where necessary, be made air and water tight. In the saloon, ward room, &c., silvered ornamental fittings are used. The machines, which are in duplicate, are by Siemens Bros., of their new shunt and series wound direct current type, giving at 650 revolutions per minute from 12,800 to 13,000 volt amperes. Their working before the ship sailed was found to be admirable, running cool, quietly, and with only very slight sparking at the commutator. The engines, to which allusion has already been made, were by J. and H. Gwynne, of Hammersmith. They are of compound type, both piston rods being connected to a common crosshead, with only one connecting rod. The speed was 650 revolutions per minute, and owing to the very limited time at the makers' disposal, some slight additions to assist the lubrication had to be made on board; still, at the time of the trials, the engines upheld the reputation of Messrs. Gwynne's well-known firm, running for hours at the above-named high speed without any indications of heating. The whole of the work has been carried out in a thorough and systematic manner, under the direction of Mr. J. F. Albright and the personal supervision of Mr. A. B. Blackburn, of the Swan United Electric Light Company, which company has at the present time a large number of ships on hand.

University College, Dundee.—On Friday, the 5th instant, this college, which has been presented to the town and endowed by Miss Baxter, of Dundee, was declared open by the Right Hon. Earl of Dalhousie. Professor Stuart, of Cambridge, delivered an opening address, in which he alluded to the prominent position occupied by higher education in Scotland as compared with other countries. He said that "there is no country in the world, with the exception of Switzerland, which is better supplied with universities than Scotland is. In Switzerland there is one university for every three-quarters of a million of the inhabitants; in Scotland, one for every million; in Germany, one for every two millions; and in England one for every six millions." He then traced the rise of universities from the earliest times to the present, and explained their object. He touched on the modern demand for technical education, and offered a few words explanatory of its meaning and

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bearing. Speaking of science in the workshop, he said:—"In order to illustrate efficiently scientific principles by means of a man's work, and thus to give him the habit of elucidating his work by means of these principles, it is very desirable that the scientific teacher should ascertain from his pupils personally from time to time what work they actually are engaged in in their workshops, and he should suggest to them certain points in it for consideration. These are problems, as it were, for them to solve; this nurses the growing notions in the pupil's mind, and helps him to see *how* to utilise his knowledge. I have been so impressed by experience with the practical utility of this step that I have for my own pupils in Cambridge—there being no engineering workshops there—erected an engineering establishment into which I turn them as pupils, and my assistants follow them through their work, from time to time point out things in their work which can be elucidated by theory, and thus turn their minds directly into seeking always how to apply their knowledge, and how to interpret by it the work that passes through their hands. I have found this—which I now carry out on a large scale—most successful. I find it makes fruitful the abstract scientific principles they have already acquired in a way which is in some cases almost astonishing. It gives a new life both to the science and to the work. It teaches them to think, and involves the true principle of education." On the conclusion of Professor Stuart's address a portrait of Miss Baxter was unveiled in the hall of the college, and subsequently the numerous guests lunched in the Albert Hall, when the usual toasts incident to occasions such as these were proposed. In the evening Professor Ewing delivered a lecture in the hall of the college to working men, taking as his subject, "Electricity as a Motive Power." We have alluded to this in a separate note. We may add here that Professor Ewing is to deliver a special course of lectures on electrical engineering during the coming winter session.

Preparing for Cheap Telegrams.—We make the following extracts from an article under this heading which appeared in the *Daily News* of the 10th inst.:—"The statement that 50,000 miles of new line will have to be constructed may approximate to the truth eventually, but at present it is a good deal in excess of what is arranged for. Outside London there will be in the main three new lines of poles extending altogether about 900 miles. One line, starting from the metropolis, will run up through Aylesbury, along the Trent Valley to Warrington, and thence to Preston and Carlisle. At the outset this line will consist of 17 wires, the number, however, gradually dropping off as the limits of the the various circuits are reached. Beyond Carlisle existing Scotch lines will be utilised. On the east of England the new telegraph will start with 14 wires, and will run up through Peterborough and York to Newcastle; while on the south a new line of poles, carrying at the outset 15 wires, will run down through Salisbury as far as Exeter. In many cases additional wires will be laid on poles already standing; this will involve an increase of several thousand miles to be added to the entirely new 900 miles of line, which may be taken to average 10 or possibly 12 wires over the whole distance. Besides which it is deemed necessary to add submarine cables to the Channel Islands, the Shetlands, and the Isle of Man. These extensions have not yet been actually commenced, but great quantities of stores of one kind and another are being arranged for. Twenty thousand poles, for instance, have been bought in Norway, and will shortly be imported into Hartlepool, where they are creosoted. Most of these telegraph posts come from Norway, and it is found cheaper to bring them into Hartlepool than to London, because the vessels they are conveyed in can always take back a cargo of coals. These and other stores are distributed at various depots. There is a chief depot in Gloucester-road, Regent's Park, and there are eight or ten others in various parts of the kingdom. In London arrangements are in progress for the setting up of about 150 additional instruments. Lines of wire will have to be laid or wires added to existing lines in some directions, but to a great extent an addition to the pneumatic despatch system will be relied upon for the busier portions of town. When this system was installed in its new quarters in St. Martin's-le-Grand some years ago, the engine power provided was a good deal in excess of what was required, and seemed likely to be equal to any probable future demand upon it. What reserve still remains, however, will now be utilised to the utmost, and it seems more than probable that before very long it will be imperatively necessary to institute another pneumatic pumping station somewhere in the West Central district. At present this is impracticable on account of the cost, the money available for the work of telegraphic and pneumatic extension being limited this year to £500,000, which will probably be absorbed in other ways. This, however, is at present very much a matter of conjecture. Emissaries from the General Post Office are now instituting inquiries at all the chief centres of telegraphic business of the kingdom with the view of ascertaining their individual requirements, and not until all this information has come in will it be possible to say what will be the approximate cost of the work. It has been decided, however, to extend to the utmost the pneumatic despatch in London, and also in Liverpool and Glasgow. . . . . When the telegraphs were taken over by Government in 1870 it was found necessary to set up a school for the systematic training of telegraphists. During the twelve or thirteen years since its institution it has turned out over 3,000 telegraph clerks—between 1,600 and 1,700 males and nearly 1,500 females—and now the contemplated alterations seem to demand a considerable enlargement of it. Hitherto about 50 boys and 30 girls have usually been under training here, and additions are now being made to space and instruments and instructors, so as to provide for a regular attendance of 100 or 120. The school is situated on the top floor of premises in Moorgate-buildings, just off Moorgate-street, at the back of Telegraph-street. All candidates for admission to it have first to present themselves to the Civil Service Commissioners in Cannon-row, in response to advertisements in the public papers. The Post Office authorities wait until they have vacancies for a considerable number, which usually happens about twice a year, and then applicants, not under 14 nor over 18 years of age, are subjected to a competitive examination in writing from dictation, handwriting, and easy sums in the first four rules of arithmetic. The number required is selected from those who get through most satisfactorily, and it has occurred before now that out of 1,000 candidates not more than 50 have been found to come up to the required standard. Those who pass are admitted to the school free of charge, but they receive no pay while there. They ordinarily acquire all that can be taught them in three or four months, working about four hours a day. It is curious to find that of those who enter there are always about eight or ten per cent. who cannot acquire the art of telegraphing. There are four instruments they are required to become proficient with—the Morse printer, the sounder, the single needle, and the Wheatstone perforator. It is found that as a rule to become a really good telegraphist it is necessary for a boy to begin not older than 15 or 16. Girls may commence a little later than boys."

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CURRENT ENERGY.—IX.

BY OLIVER HEAVISIDE.

(CONTINUED FROM PAGE 416.)

The equation already given for the total E.M.F. in a thermo-electric circuit of two metals (equation (2) p. 415) in terms of the Peltier and Thomson forces, or the reversible heat effects per unit quantity of electricity at the junctions and in the unequally heated parts of the separate metals respectively, involves no hypothesis. If we could measure the values of PQ and of σQ (the Peltier and Thomson heats produced by the passage of any quantity Q of electricity) for all pairs of metals, and at a sufficient number of different temperatures, thus obtaining P and σ as functions of the temperature, we should have all the data required for the calculation of the thermo-electric force in any metallic circuit. But at this point of the inquiry a remarkable speculation of Sir W. Thomson comes in, furnishing an excellent example of the great aid to be derived from mathematical theorising in giving a direction to experimental inquiry and facilitating the practical completion of the theory. For the science of thermo-dynamics, which at the time of its application to thermo-electricity had only just been established on correct principles, furnishes information as to a relation between the Peltier and Thomson effects and the temperature, which, though not amounting to strict demonstration, is yet of great probability and suggestiveness.

There are in thermo-dynamics two fundamental laws. The first expresses the equivalence of heat and work, an example of the principle of conservation of energy, and first applied to thermo-dynamics by Clausius. Let a substance be made to go through a cycle of changes, at the end of which it returns exactly to its original state, having during the cycle been varying in pressure, temperature, and volume, and receiving or losing heat during its changes of temperature, and doing external work or having work done upon it by its pressure during its changes of volume. Let H_1, H_2, ..., be the amounts of heat successively given to the substance, heat given out being reckoned negatively, and let W be the whole external work performed by the substance during the cycle, then $\Sigma H = W$ expresses the first law of thermo-dynamics. If ΣH be positive, or heat be given to the substance on the whole, it is accounted for by the external work done by it during the cycle, since the body is in the same state at the end as at the beginning, and contains the same amount of heat, whilst if ΣH be negative, there has been work done upon the substance. In the first case heat is transferred from higher to lower temperatures, in the latter from lower to higher. Any such arrangement is a heat engine, by means of which work may be obtained from heat, or *vice versâ*.

The mathematical expression of the second law is $\Sigma H/t = 0$, when the cycle of operations is completely reversible, t denoting the temperature at which the quantity H of heat is given to the substance. It is a consequence of Carnot's reasoning regarding reversible heat engines, when his erroneous assumption of the materiality of heat is discarded, and the equivalence of heat and work admitted in its place. As shown by Carnot, the test of perfection in a heat engine is its perfect reversibility. Thus, if it work between the temperatures t_1 and t_2 on any scale, the working substance receiving heat of amount H_1 from a hot body at the higher temperature t_1 and giving out an amount H_2 to a cold body at the temperature t_2, and performing therefore $W = H_1 - H_2$ of work in a cycle; and if the operations be completely reversible, so that by doing W of work on the substance, H_2 of heat is taken from the cold body and the greater amount $H_1 = W + H_2$ given to the hot body, such an engine is perfect; in this sense, that no other engine can possibly do a greater amount of work with the same supply of heat and working between the same temperatures. If there could be an engine B which should have a greater efficiency than a given reversible engine A, the two might be coupled, both working between the same temperatures, B working direct, receiving H_1 of heat from the hot body and driving A backward (since A is reversible) with an excess of useful work. For B would do more work in its direct action than would be needed to drive A backwards and give back to the hot body the heat H_1 which B received therefrom, and we could thus obtain a perpetual supply of work from heat at the lower temperature, *i.e.*, without letting heat down from a higher to a lower temperature, which is admittedly impossible.

It follows that all heat engines working between the same temperatures have, if they are reversible, the same efficiency, or, in other words, the efficiency is independent of the nature of the working substance, and depends only upon the temperatures between which it works. *I.e.*, the ratio $W : H_1$ is a function of t_1 and t_2 only, or, more conveniently, the ratio $H_1 : H_2$ is a function of t_1 and t_2 only. The nature of this function could therefore be found by experiment upon any substance.

Now, if the substance be air, and the scale of temperature be that of the air thermometer, whose zero is 273°C. below the freezing point of water (air and other gases expanding nearly alike in the ratio 273 : 373 when raised from 0° to 100°C. at constant pressure), then, by the known gaseous laws, and with the assistance of the experimentally known fact that a gas in expanding from one volume to another requires no heat (or nearly none) to be supplied to it to keep its temperature from falling (unless it be performing external work during the expansion, when an equivalent amount of heat must be supplied to the gas), it is easily shown that the ratio of the heat supplied to the substance at the higher to that given out by it at the lower temperature, when working reversibly, is simply the ratio of the temperatures. That is, $H_1 : H_2 = t_1 : t_2$; or $H_1/t_1 = H_2/t_2$. And, extending this to any reversible cycle, reckoning heats given out as negative, the corresponding equation is $H_1/t_1 + H_2/t_2 + H_3/t_3 + \ldots = 0$, or simply $\Sigma H/t = 0$, each amount of heat being divided by the temperature at which it is supplied.

This, however, depends for its accuracy upon the degree of closeness with which air fulfils the gaseous laws, and also the above-mentioned property of requiring no supply of heat when expanding to keep its temperature constant. Some gases cool a little, others heat a little in expanding, and the gaseous laws are not perfectly fulfilled by any gas. Hence, although $\Sigma H/t = 0$ is very nearly true whatever be the nature of the working substance when the temperature is reckoned by the air thermometer, yet it is not exactly true. It would be exactly true with an imaginary perfect gas for thermometer. But, by actually *defining* the scale of temperature so as to make $H_1 : H_2 = t_1 : t_2$, when an engine works reversibly between any two temperatures t_1 and t_2, we have a scale which is independent of the properties of any particular substance, which is Sir W. Thomson's scale of absolute temperature. It is practically the same as that of the air thermometer.

In a thermo-electric circuit we have reversible heat effects, resembling those taking place in the cycle of a reversible heat engine. Thus, in a circuit of two metals, if we make the temperature t_1 of one junction a little higher than t_2, that of the other, and if P_1 and P_2 are the corresponding Peltier forces, there is absorption of heat P_1Q and generation P_2Q at the hot and cold junctions respectively during the transfer of the quantity of electricity Q by the current set up, their difference $(P_1 - P_2)$ Q being expended in uniformly heating the circuit according to its resistance. Here P_1Q corresponds to H_1, the heat given at temperature t_1 to a substance working reversibly between t_1 and t_2, and P_2Q to H_2 the heat given out at the lower temperature, whilst $(P_1 - P_2)$ Q corresponds to $H_1 - H_2 = W$, the work done by the substance. In both cases there is transference of heat from hot to cold, with performance of work. But the heat developed "frictionally" in the wire by the current is not a reversible operation. To make the correspondence complete, we must suppose that when the heat engine does W of work, it immediately converts it into heat again by working against frictional forces.

And, as we may work the engine backwards, transferring heat from cold to hot, taking H_2 from the cold body, and giving $H_1 = H_2 + W$ to the hot body, so we can, in the thermo-electric circuit, by sending a current through it in the opposite direction to and of greater strength than the natural current, carry heat from the cold to the hot junction, absorbing P_2Q at the cold and generating P_1Q of heat at the hot junction during the passage of Q.

There is also the ordinary conduction of heat going on,

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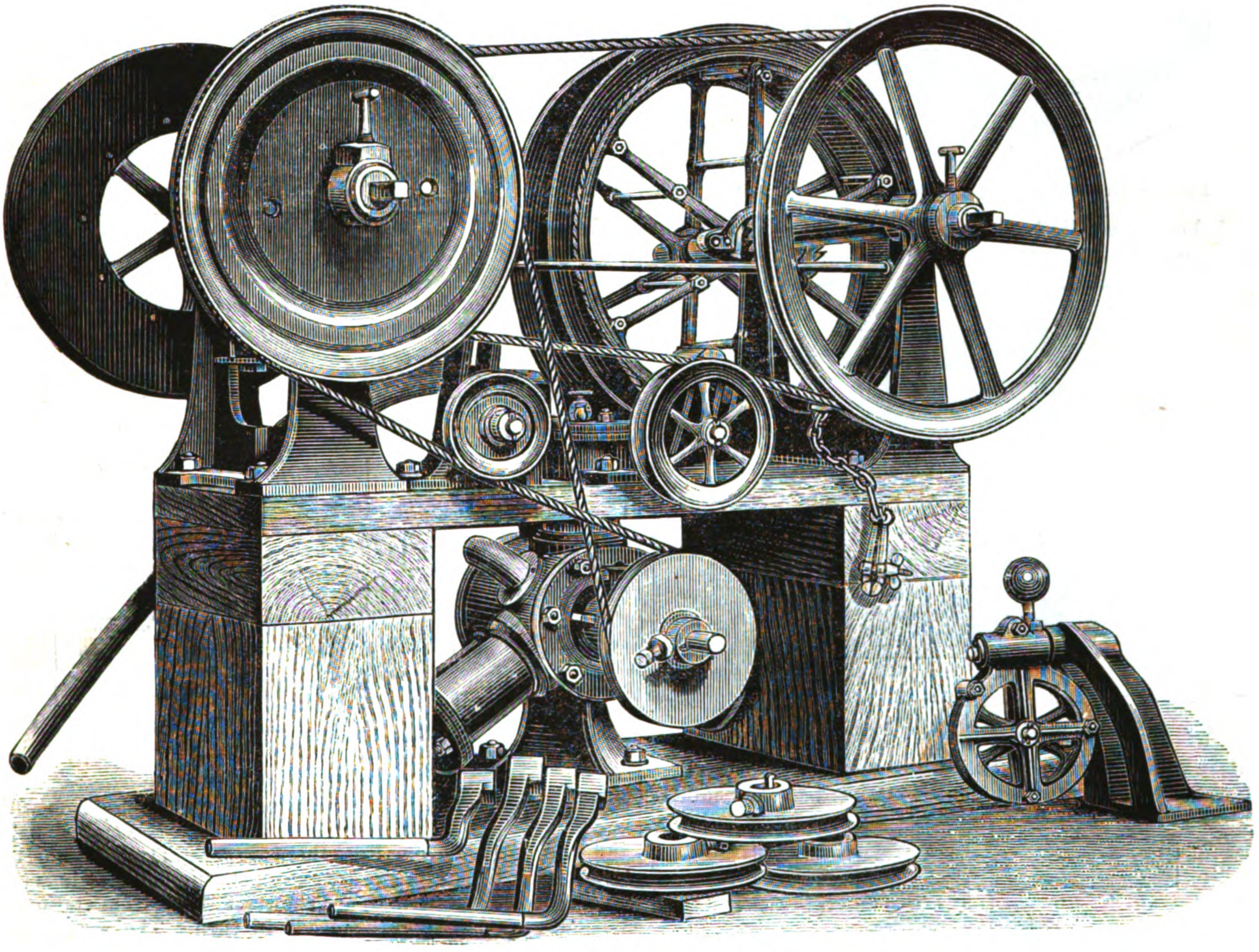
which is essentially of an irreversible nature, and it may be of far greater magnitude than the reversible effects. But this is completely ignored in applying the second law to the reversible effects, and is considered to have no influence on the phenomenon.

(TO BE CONTINUED.)

DEEP SEA SOUNDING MACHINE.

We illustrate a machine of the most modern type for taking soundings with great rapidity in the deepest water, on Sir William Thomson's well-known principle, that of employing a small steel wire instead of a hempen rope. The engraving is from a photograph of the machine, which has been adopted by most of the leading Submarine Telegraph Companies, the Eastern Telegraph Company's vessel the "Volta" being among the last to be equipped with one of them. This, and a smaller machine which is only for water up to 500 fathoms deep, is made by Messrs. Johnson and Phillips, from the designs of Mr. F. R. Lucas, and they are the result of a long and varied experience of deep sea sounding machines in connection with submarine telegraphy. Messrs Johnson and Phillips inform us that they were supplied for the late Polar expedition under the command of Sir George Nares, who suggested some improvements in details, which have been adopted by the makers.



Johnson and Phillips' Deep Sea Sounding Machine.

It will be seen that in the lower part of the framing is a three cylinder steam engine, which is used for picking up the wire. The engine is supplied with steam from the main boilers, and is conveyed to it though a flexible steam hose, which is readily joined to a suitable connection in the winch pipe on deck. This machine will carry wire for the greatest depths, say 3,000 to 4,000 fathoms. The machine appears to be very carefully constructed, and we note that the drum carrying the wire is entirely composed of steel and gun metal, so as to be as light as possible.

NEW CURRENT AND POTENTIAL INDICATORS.

We this week illustrate some new electrical measuring instruments, the joint invention of Mr. R. E. B. Crompton and Mr. Gisbert Kapp, in which the permanent magnets hitherto used in current and potential galvanometers are replaced by electro-magnets.

The ordinary ammeters and voltmeters, handy instruments though they undoubtedly are, have the drawback of requiring frequent calibration in order to ascertain whether the strength of the permanent magnet has not altered. In doing away altogether with a steel magnet and substituting an electro-magnet for it, which is excited by the very current which is to be measured, the inventors have succeeded in producing instruments which, once correctly calibrated, remain so for ever.

The current indicator is shown in plan in Fig. 1, and the potential indicator is shown in plan and elevation in Figs. 2 and 3. In the first-named instrument the current enters at the terminal plate *a*, traverses to the right and to the left the coils W W of the circular electro-magnet, and is finally led back by the conductor D D into a terminal plate parallel with and close under plate *a*, but separated from it by a sheet of insulating material. The deflection of a pivoted magnetic needle N S (as indicated by a light aluminium pointer on a large dial not shown in the figure) indicates the current. Upon tracing the direction of the current it will

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be seen that the circular electro-magnet tends to make the needle place itself in line with the projecting pole pieces P P, whilst the conductor D D, which is situated at a certain dis-

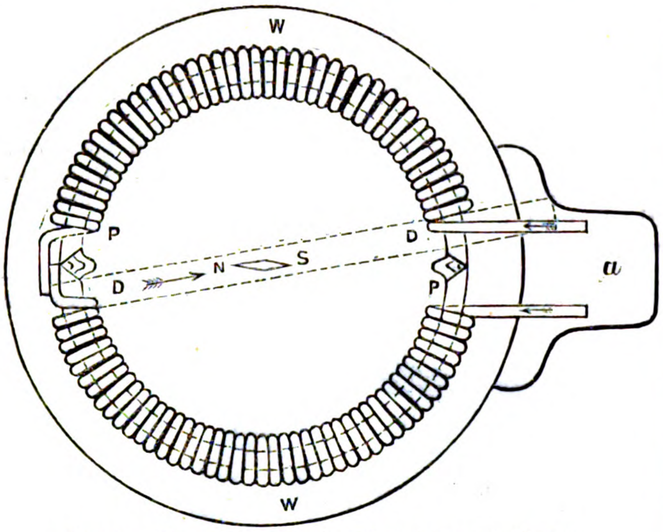


Fig. 1.—Plan of the Crompton-Kapp Current Indicator.

tance below the needle tends to set it at right angles to itself.

The mass of iron in the core of the electro-magnet is so

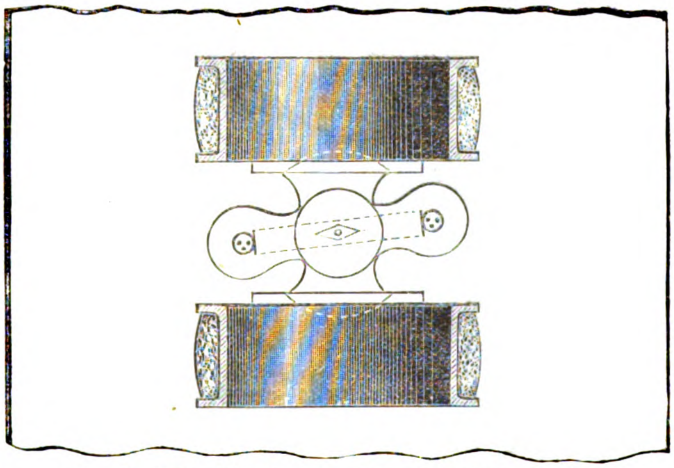


Fig. 2.—Plan of the Crompton-Kapp Potential Indicator.

small in comparison to its exciting power that the smallest current for which the instrument is intended already suffices

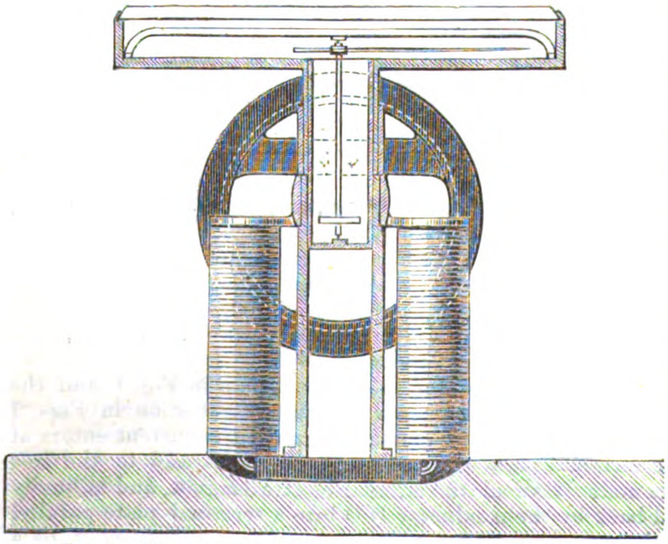


Fig. 3.—Elevation of the Crompton-Kapp Potential Indicator.

to saturate the core. In consequence of this the directing power of the magnet is nearly constant for all currents, and as the deflecting power of the conductor D D is simply proportional to the current, it follows that the needle will set itself at a definite angle for each current. It will be noticed that the conductor D D is not parallel to the zero position of the needle, but swivelled at a certain angle. The object of this arrangement is to balance the magnetic influence of the coils W W themselves, so that only that part of the directing power which belongs to the iron core, and which is nearly a constant, affects the needle.

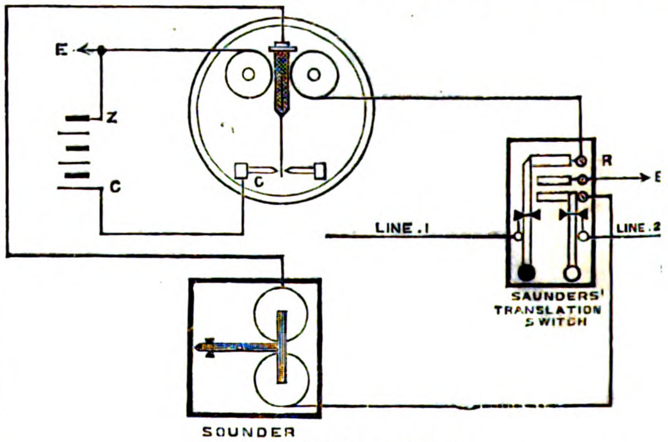
The potential indicator is constructed on the same principle, but with this difference in detail, that instead of few turns of stout wire, many turns of fine high resistance wire are employed to excite the electro-magnet (here of horseshoe form), and, instead of a single conductor, two circular coils of fine wire are used for producing the deflection of the needle. These coils, as will be seen from Fig. 3, are also set at an angle.

Either instrument can be provided with differential shunt coils in the proportions of one to nine, whereby the range of readings is multiplied tenfold. The position of the pointer to one or the other side of the dial also indicates the direction of the current, and if alternate currents are to be measured the magnetic needle N S is replaced by a needle of soft iron.

Messrs. R. E. Crompton and Co., of Chelmsford, are the makers of these instruments.

FORSTER'S TRANSLATION FOR CABLE WORK.

Anybody who has worked through translation can testify that even by the most approved systems, and with the most



Forster's Translation System.

thorough supervision of experienced hands, occasions will, and continually do, arise of "sticking" or "failing" signals, and where on some long lines there are several translations, recriminations from all sides are extremely rife, and blessings (?), both loud and unmerited, are showered down from station to station, each blaming the other in turn. The writer, who has seen a great deal of translation service with apparatus perfect both in principle and workmanship, but which has often failed in its *practical* results, considers that the system to be explained in this paper has certainly greatly remedied if not thoroughly cured, the tantalising remarks so unfortunately in vogue on translation circuits, by removing the cause of complaint.

As, of course, is well known the line current of any translator is taken up at the armature by contact made on the stops which regulate its play, and more frequently, in order to ensure a more perfect resemblance to "key" signals, the contacts are prolonged by springs, or take up a "double current," as the case may be.

Now, although an operator apparently *sees* the entire current passing out to line on his galvanometer, and although, apparently, the armatures and their springs beat with extreme precision, and with sufficient strength on to the battery contacts, how often does the next station fail to receive the entire signals, and endless repetitions, serious delays, and bickerings are the result.

By the Forster system this is entirely avoided, as a

glance at the diagram of connections will show, one end of the coils of the sounder being connected to the tongue of the relay, and the other end to the translating switch. Instead of the relay which receives the incoming current actuating a Morse by a local battery to transmit the outgoing current, the outgoing current is sent by the relay itself through the coils of a sounder and thence to line.

Now, it is very clear that unless the *full* strength of the battery passes out through the "sounder" the signals on the same are unreadable, and the clerk must regulate accordingly, and when the signals are perfect you hear them exactly as they pass out to the opposite station, and, inasmuch as the "ear" is so much more certain than the "eye," on this head alone there is a great advantage.

The receiving station can no longer complain of your regulation, for hearing the perfect outgoing of your signals you can prove to him that *his* apparatus and not your own is faulty.

The pitch of the sounder can be fixed at pleasure; its functions are simply to replace the deceptive galvanometer in checking the outgoing signals, and for the supervisor to copy passing telegrams when requisite.

The old adage of "there being nothing new under the sun" is probably more applicable to telegraphy than to any other art, and the writer describes this system with trepidation, although he is unaware of it having ever before been applied.

It is not only a theoretical but a practical success, and has been giving splendid results at Zante Station on cable sections of 170, 190, and 320 knots without ever once failing.

Exception may be taken by some to the increased resistance in circuit caused by the insertion of the "sounder;" practically it makes not the slightest difference.

In sections of 2,500, 2,800, and 4,000 ohms resistance, a sounder of 200 or 700 ohms has been used apparently without the slightest change in the signals received at the further stations. The system at Zante is actually being worked with a sounder of 200 ohms resistance.

Another great source of trouble with existing systems of translation is the variation of the E.M.F. of the line battery, according to the length of time the cells have been in use. Very little or nothing can be detected by the galvanometer, as the impetus of the needle itself causes it to oscillate equally as well, even although the battery may have lost half its strength; but when the outgoing signals pass through your sounder you have every inflection of its beat, and the slightest inconstancy or loss in strength is immediately detected and can be remedied; for instance, at Zante the translation battery of ten Fuller cells may remain untouched and thoroughly constant for months, and then the E.M.F. will begin to vary. This is at once noticeable on the sounder, but never on a detector.

Another striking feature in favour of this system is the adoption of one relay and one sounder for all circuits.

With either of one of those beautiful relays the Brown or the Theiler, a constant regulation can be maintained for any current after it has been once adjusted to the minimum saturation strength of the longest circuit. For example, by a certain method the incoming current on the translating relay at Zante, whether double or single, or whether it passes over a section of 170 or 320 knots in length, comes out equally as well, and there is never the slightest necessity to re-adjust the instrument when either of these circuits are switched on to it.

It is obvious, for many reasons, that the fewer apparatus in the circuit the better, and when one relay only is used the chances of faulty adjustment are reduced to an absolute minimum. Each circuit is changed over from relay to sounder by Saunders's excellent but simple switch, and inasmuch as no translation is or ever should be left without constant supervision, any objection against it is groundless.

Curiously enough the speed attainable by this system is considerably higher than where each section is being worked from the key.

Such high flights are taken in theory nowadays and are rarely ever successfully worked out, that any practical innovation whereby actual material advantages are obtainable is extremely welcome.

CORRESPONDENCE.

ANIMAL MAGNETISM.

TO THE EDITOR OF THE ELECTRICIAN.

Sir: The more elevated the position of a man of science, and the higher the platform from which he enunciates his opinions, the more, if those opinions are correct, does he command the respect of the public.

The Electrician of September 29th contains an abstract of the lecture delivered at the late meeting of the British Association by Professor M'Kendrick, F.R.S., Professor of Physiology in the University of Glasgow, &c.

Dr. M'Kendrick is reported to have stated that "all attempts to influence the living body by means of magnets had no rational basis;" and again, that "the so-called phenomena of animal magnetism are of an entirely different kind from those discussed. These are of a subjective character dependent upon peculiar states of the nervous system, having nothing whatever to do with electricity or magnetism, but still, in a sense, they are phenomena as real as those of physical science. Their subjective character, however, renders them specially difficult of investigation, and consequently they are more liable to fall into the hands of the charlatan."

Now, sir, the platform from which I write is exceedingly humble, but since for upwards of twenty years I have devoted my leisure time to the study of animal life and its connection, or otherwise, with physical force, I trust you will allow me space for a brief statement of facts which entirely confute the negative evidence and opinions of Professor M'Kendrick, however honestly and in good faith his statements are made.

It is right I should state that I base my conclusions in great measure upon some original work which I have done* in what may be designated as the primary principles of physiology and magnetism, and I now consider that I have sufficient grounds to justify my asserting that animal and vegetable life, magnetism, and every other form of physical force are the outcome of one primary motion, viz., the motion of the earth; and further, that the absence of any marked phenomena from the application of powerful electro-magnets to the animal body is capable of complete explanation by reference to well known physical laws.

As briefly as possible I will enumerate some of the data upon which, taken in connection with the experiments referred to above, I base my conclusions, and show the intimate connection which subsists between that force which maintains animal life and that which is known as magnetism.

1. The earth is a magnet.
2. Every form of matter is pervaded with and has a certain capacity for this magnetic force of the earth, the capacity varying with the molecular composition and other physical conditions of the matter.
3. Every form of matter transmits the force in lines which are characteristic of the matter.
4. The first principles of magneto-electricity depend upon the recognition of the fact that, when matter is moved through the lines of force emanating from a magnet, force is generated in the matter in a degree proportionate to the intensity of the magnetic force, the character of the matter, and the rapidity of the motion.
5. All animal life is accompanied by motion of matter, and this motion is molecular, probably atomic also. With but few exceptions in the lower forms of animal life, the moving matter is composed of a nutrient pabulum and a corpuscular portion. The latter, as shown by Dr. Gamgee, F.R.S., is highly magnetic, both in the venous and arterial states. The paper on the magnetic states of arterial and venous blood to which I have referred above proves that the arterial blood corpuscles contain more magnetic force than the corpuscles of the venous blood, a very important point,

* 1. Experiments showing the magnetic states of arterial and venous blood. *Proceedings of Royal Society*, 157, 1875.
2. New method of investigating the magnetic lines of force in magnets. *Proceedings of Royal Society*, 1879.

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for in proportion as the corpuscles are more magnetic they radiate magnetic force to a greater distance, and as the arterial blood corpuscles alone have the power of rousing energy in the nerves, we may justly attribute the nerve power to the magnetic force of the arterial corpuscles.

6. According to the physical laws referred to above, it is impossible that the blood can move over the tissues in a state of health, and through the lines of terrestrial magnetic force which permeates those tissues, without originating force in the tissues—force which is similar in its character to the vibrations which are transmitted by the telegraph and telephone wires, and which force must correspond in velocity with the force resulting from the motion of the blood corpuscles.

7. When these tissues exist in continuous lines, as in the nerves, muscles, &c., currents must be generated, and the rate of transmission must vary, other things being equal, inversely with the resistance which each tissue offers to the transmission of force.

8. The nerve current or nerve power which regulates all the processes of life, mental and corporeal, is in exact proportion to the oxygenated and magnetic condition of the arterial blood; therefore we can have no hesitation, as it appears to me, in referring such nerve current to the motion of the blood corpuscle in accordance with the principles of magneto electricity.

9. By way of testifying to the influence which terrestrial magnetism exerts upon matter generally, I may here mention that some years since I had a coil of wire constructed and so mounted upon a pivot that it could be rotated upon an axis at right angles to the direction of the strands of the wire when turned to any point of the compass.

This coil is placed in connection with a Du Bois Reymond galvanometer, and the slightest inclination of the axis to the north or south gives a corresponding deflection of the galvanometer needle. The motion of the coil in this case gives motion to that quantity of magnetic energy which it possesses in virtue of its being a portion of the mass of the earth in a line determined by the direction of the strands of the wire.

10. When artificial magnets are applied to the surface of the body, the terrestrial magnetic energy or force passing through the body is increased in direct proportion to the power of the artificial magnets, and the molecular motion which is taking place in the tissues subjected to the action. In no case, however, can this molecular action be increased by the application of such magnets except in so far as the capacity of the molecules enables them to interfere with the magnetic force. For instance, a certain degree of magnetic polarity is, as I have already shown, inseparably connected with each molecule, and so long as the molecule is not affected by the motion of the blood, or by motion of any other particle, there is no disturbance of that polarity either in the animal body or in any other form of matter; but when motion does take place the magnetic phenomena must accord not only with the molecular motion, but with the character of the moving matter.

11. If I am right in the above conclusions then the germ of a living cell directs the subsequent development of the future cell, in consequence of a grand physical law which appears to pervade all matter, viz., that matter exerts a directive influence upon force; and there are reasonable grounds for assuming that benefit will accrue from the artificial magnets in proportion to the influence which the natural germinal matter is capable of exerting under increased energy in expelling those elements which have been deposited as impurity.

The science of therapeutics has not yet attained perfection, and I venture to predict that its great mysteries will remain until the physical nature of that force which carries on animal life has been fully established. I am no materialist in the sense in which that word is so generally used; nay, more, I fully recognise that the various forms of matter were created out of one description of matter—as put forward by Clerk Maxwell and others—with the object that each should play its part in the evolution of those phenomena which are natural to the earth, precisely upon the same principle as the various portions of an ordinary mechanism tend to effect the general work of a machine.

I trust I have said enough to prove that I do not advocate the appliance of magnetism upon the principle of the charlatan, which must be the case if the teaching of Professor M'Kendrick is correct, and, as a great principle is involved in the question, I trust Dr. M'Kendrick will acknowledge the soundness of my views, or show me in the pages of a scientific journal wherein I have gone astray.—Yours, &c.,

RICHARD C. SHETTLE, M.D.

Reading, Oct. 4, 1883.

NEW UNIPOLAR DYNAMO.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In writing on the above subject Mr. Bandsept conveys the impression that Mr. Floyd Delafield's is the first electro-motor having an "armature without wire." What

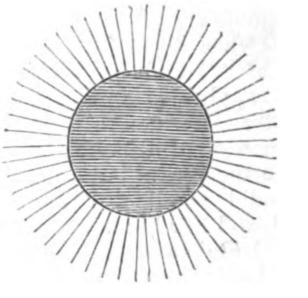

FIG. 1.

is a magnet rotating on its own axis but an electro-motor without wire? This is the principle on which the Delafield machine is evidently based. Although the armature consists of a copper cylinder the action is precisely the same as that of the rotating magnet, inasmuch as the outer surface of the latter acts as the conductor, the magnetism which it contains being independent of it and stationary, whilst the iron which holds the magnetism rotates. This may be compared to a cylindrical vessel filled with liquid (Fig. 1). For convenience we will imagine the liquid to be capable of developing lines of force similarly to a permanent bar magnet. Gravitation would tend to keep the liquid and its supposed lines of force at rest, whilst the cylinder, by being rotated, would cut them the same as a cylindrical bar of steel cuts the lines of force of the magnetism which it holds in its homogeneous molecules, and similarly to a rotating copper cylinder under magneto-inductive action.

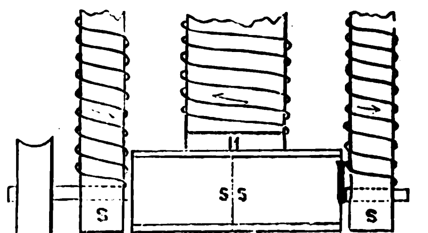

FIG. 2.

The fact is the Delafield machine is simply a modification of the Siemens unipolar machine, known to most of your readers, and, I think, recently illustrated in your journal. By referring to my specification (No. 1794—1882) Mr. Bandsept will see that I also have been in the field.

In the account of the Delafield machine which appeared in the *Scientific American* the polar signs were not shown, but so far as I can see by the position of the collectors there is only one way that it would be possible for a current to be obtained. Fig. 2 will explain. The maximum polarity of the armature core is at the dotted line at the middle, and if cut asunder there its two halves may be considered as polar extensions of the armature electro-magnets S S.

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The field magnet N increases the polarity of the armature by induction. It is obvious that if longitudinal sections of the cylinder were moving upwards at the top and downwards at the bottom, the current would enter at one end of the armature and go out at the other in the direction indicated by arrows.

I cannot help thinking that Mr. Bandsept is most unjust to many inventors and others when he says: "It is certainly not enough to publish a new idea; and the simple enunciation of a principle differing from that which is generally accepted gives no actual right to the person laying it down. The merit is conferred, on the contrary, on him who can carry out the principle."

There is some truth in the last remark. According to this reasoning Faraday and all the great scientific discoverers of the past should be remembered as of secondary importance, and the man who designs a new machine should take a back seat, whilst he who carries it out should be mounted on a pedestal. The next thing would be to fall down and contemplate the lathes (æsthetic fashion) and the numerous mechanical tools that play such an important part in facilitating the construction of new inventions.

Mr. Bandsept seems to forget that to design a new machine only requires knowledge and mental constructiveness on the part of the designer, which at a cost of a few shillings can be transferred to paper, thus enabling thousands to carry it into effect. To do the latter, however, requires more or less capital—generally more. In electrical matters just at present there are three factors that prevent an inventor from getting

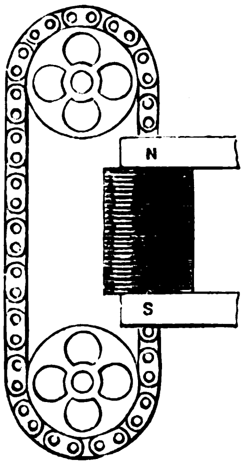

Fig 3.

capital—(1) an apathetic public that has been unmercifully fleeced by company promoters, (2) unwarrantable prejudice, (3) vested interests. The latter, probably, is beneficial, as it prevents a too rapid change; but, of course, all these must in the long run give way to the inevitable progress. In the meantime they prevent the enunciators of "principles" not "generally accepted" from carrying such principles into effect, and thereby are the means of depriving inventors of the merit which they deserve.

Mr. Bandsept tells us that he has been working out a receiving machine or electro-motor, his object being apparently to obtain a continuous rotatory motion without commutator and without change of polarity. This, he says, "can be realised by causing a Siemens bobbin to revolve inside a fixed Gramme ring in which the poles alter their position section by section, those of the bobbin remaining unchanged." It would be interesting to know what possible advantage there could be in such a machine, and in what way the commutator and brushes could be dispensed with. The Siemens bobbin would evidently act as the inducing magnet in this case, and as it would be limited in size it would be necessary to have auxiliary field magnets on the outer side of the ring, and to make them rotate with the bobbin. This would simply be a Gramme machine with the armature fixed, while the field magnets revolved *carrying the commutator brushes round with them.* No one would think of working a Gramme machine in this fashion. It would be like moving the mountain to Mahomet.

We are also told the above expected results "can also be obtained, other things being equal, when one of the portions of the ring—the cylindrical core—alone is caused to move and is set in motion under the combined action of the ordinary inducing poles and the two poles created in the soft iron by a fixed solenoid." Mr. Bandsept will see by referring to my specification (No. 4567—1882) that I have been studying in this direction; and I venture to think when he puts his machine to trial with a *continuous* cylindrical core he will get no movement. In the American Gramme patent there is a drawing of a machine consisting of a flexible soft iron core (Fig. 3) composed of links forming an endless chain, and supported by two pulley wheels. The chain is made to pass through a fixed solenoid, which magnetises the core as it passes through. At the same time the permanent magnets N. S. tend to induce opposite polarity in that part of the core, and a movement of the latter is supposed to be the result. It is difficult to see how a movement could take place, however, because, after all, iron is but a receptacle for magnetism, and where the iron is infinitely long, as in the endless chain, the induced magnetism in it, caused by the solenoid, would be acted upon by the permanent magnets without moving the core, that being homogeneous in structure, allowing the conflicting polarities induced in it by the solenoid and magnets respectively to find their equilibrium without giving any indication of a movement.

The following experiment will prove the matter. A long rod of soft iron is passed through a solenoid and floated in water by means of corks (Fig. 4). The internal diameter of the solenoid is large enough to allow the rod to pass freely one way or the other. It will be found, however, that when the bobbin is connected with a battery the rod remains at rest, but if the rod consists of alternate lengths of iron and

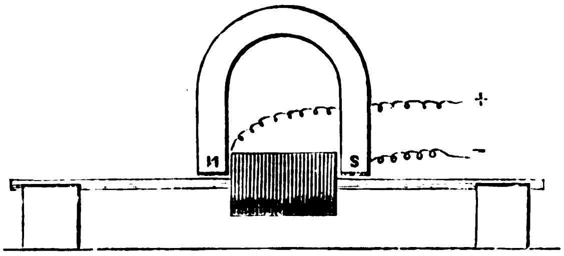

Fig. 4.

brass, each piece of metal being about the length of the bobbin, the rod will shoot through with considerable force. I have designed a motor and dynamo on this principle, and, so far as can be seen from Mr. Bandsept's communication, he seems to be after the same thing; but as I have been unable to get a machine made, I shall be greatly interested in any trials that Mr. Bandsept may make, and if published in your journal, it could not fail to interest your readers.—Yours, &c., E. L. Voice.

London, Oct. 6, 1883.

AYRTON AND PERRY'S MOTORS.

TO THE EDITOR OF THE ELECTRICIAN.

Sir: In reply to the inquiry of your correspondent last week, Professors Ayrton and Perry's patent electro-motors, weighing about 36lb., are ready for immediate delivery, singly or in quantities, at the following address. They are at present made of three types, to work respectively with 25 volts, 50 volts, and 100 volts.—Yours, &c.,

Alexander Wilson.

Telpher House, 73, Great Eastern-street,
London, E.C., October 10, 1883.

ELECTRIC BATHS.

TO THE EDITOR OF THE ELECTRICIAN.

Sir: We shall be glad if you or any of your readers will kindly tell us where we can get the latest and best book on electric baths.—Yours, &c.,

Rennick, Kemsley, and Co.

4, Finsbury-circus, London, E.C., Oct. 4, 1883.

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THE ELECTRICIAN.

TO CORRESPONDENTS.

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BETTING AND TELEGRAPHY.

During the closing days of the Parliamentary Session the telegraph in its relation to sporting affairs formed the subject of one of those amusing episodes which sometimes enliven the weary hours of question time. Somebody wanted to know—it might be thought invidious to mention names—whether it was true that the police had been taking steps in respect to certain public houses which supplied their customers not only with liquids for the body, but with food for the mind in the shape of telegraphic intelligence. The honourable member and those who supported him knew perfectly well that this was "true;" but to ask whether a thing is true is nowadays the parliamentary way of protesting one's inability to believe what, from the questioner's point of view, ought to be incredible. The police had threatened these over hospitable hotels with the loss of their licenses if they did not discontinue the use of the telegraph, lately introduced on their premises, for betting purposes. Boniface has many friends, and sport has almost as many; consequently there were no lack of voices ready to interrogate the Home Secretary on a matter of such social, not to say political, gravity. Publicans have votes, and publicans' customers have more; it is therefore inexpedient and even monstrous to do anything that might alienate the owners from their true political friends; or, to put it differently, it might be worth while to emphasise their present alienation so as to add one more proof of who were the publicans' best friends.

Except on some such political grounds as these it would seem almost impossible to account for this ostentatious championing of the publicans' cause. The law is well known, and it may be supposed that it is the publicans' affair to see that the law is not infringed. And this, indeed, is the right view to take of it. The action of the police is not likely to interfere with legitimate trade, telegraphically or otherwise. The interest in the news which is supplied will not abate in the least by reason of police interference, and there will still be plenty of establishments competing with each other in catering for the wants of their sporting customers. What this introduction of "slip" really does affect is the publicans' responsibility, one more burden being added to his already heavily weighted shoulders in the exercise of more vigilance to prevent tap-room gambling. The friends of telegraphic enterprise need be under no apprehensions on the score of loss of trade. As to the publicans' friends, one may venture to ask whether they imagined that the atmosphere of a betting house would be purified by the introduction of the telegraph? or that an inoffensive house might become an offence with impunity because a telegraph instrument had been added to the fixtures? They could hardly think so, and they have only themselves to blame if they have allowed special facilities for betting intelligence to develop into a special amount of betting on the premises. It may be difficult to draw the line at the right place; but that is the case with the drunken customer, and the betting customer cannot be more troublesome to deal with than he. Probably some of the persons now under threats from the police have introduced the telegraph solely with a view of recruiting their customers from among a certain class of men whose presence is very apt to compromise the place in which they freely congregate. If so, the publicans have shown more enterprise than foresight, and they must amend their ways without expecting sympathy either from Parliament or the public.

There is only one other ground on which exception is sometimes taken in regard to these betting facilities. It is a fact that the aristocratic clubs, as they are called, do enjoy these facilities unmolested, and that any man who is wealthy enough can have the telegraph laid on to his premises like gas and water, and may use it for betting purposes without risk of interference. But any working men's club might have the same facilities—and every working man for that matter—without interference from the police so long as they were not employed for unlawful purposes—that is to say, for gambling. The law does not attempt to prevent a man, be he artisan or aristocrat, from taking or laying the odds as often as he pleases, but it does endeavour to discourage the practice as such, and especially in the interests of those who are least able to manage their own affairs, and most exposed to the evil consequences of a bad habit. It discourages gambling just as it discourages drunkenness, without, however, interfering with personal liberty. That the law—in other words the policeman—is more watchful of the public house than of the club is both natural and just. The *habitué* of the club may be left to take care of himself, the frequenter of the sporting bar requires to be looked after at a certain stage of development, for what is at first pure sport is apt to grow into a passion ruinous to somebody or other in the long run. If one may judge by the condition of the pavement of Fleet-street on the afternoon of any great "event," the

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police authorities are not over harsh in administering the law. It is true there is no betting going on there, but the evidence of its having gone on somewhere is painfully forced upon us by the crowd of dismally anxious faces which peer into the windows of the sporting newspaper offices. When next the friends of the sporting publicans purpose attacking the Home Secretary on the subject of telegraphic facilities for betting houses we should recommend them first to take a walk down the thoroughfare we have just named any summer afternoon between Chancery-lane and Ludgate-circus. They will probably return with the conviction that the telegraph has already quite enough to answer for, and that its assistance to the betting fraternity might be even curtailed without much harm being done either to liberty or property.

SECONDARY BATTERIES; AND, AN ECONOMICAL METHOD OF GENERATING STEAM FOR ELECTRICAL AND OTHER PURPOSES.*

BY C. H. W. BIGGS, F.C.S., AND W. W. BEAUMONT, C.E.

(CONCLUDED FROM PAGE 496.)

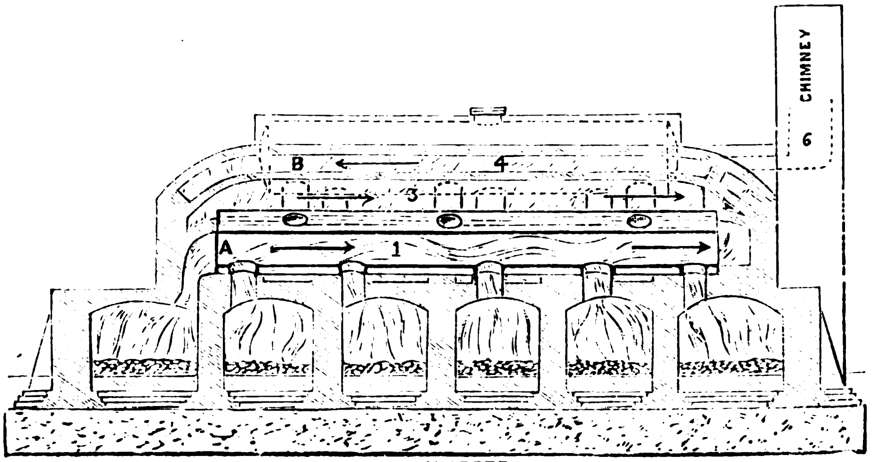
The second part of this paper is not very closely connected with the first, treating as it does a different subject, but being short it was thought they might be read together.

One of the largest items in the cost of electric lighting is that representing the cost of the generation of steam. In an installation requiring only 1,000 indicated horse-power, the coal consumed at the rate of 2¼lb. per indicated horse-power per hour for an average of six hours per day throughout the year would amount to six tons per day, or forty two tons per week. For good steam coal this represents in London an expenditure of about £40 per week, or over £2,000 per year, a sum which equals 5 per cent. per annum on a capital expenditure of £40,000.

It is the object of this part of this short paper to show that the cost of electricity may be reduced by the whole of the expenses at present incurred in the generation of steam for supplying the engines by which dynamo electric machines are driven, especially when they are used on a large scale. For this purpose reference will be made to a large boiler which has successfully produced steam sufficient for a hundred and twenty-five indicated horse-power wholly free of cost, and which has been at work daily for considerably more than two years.

In the ordinary process of the manufacture of furnace coke a quantity of combustible gas is given off which is not utilised. By a suitable combination of special boiler with furnaces designed for the production of coke, these waste gases may be, and are by the boiler referred to, utilised in the generation of steam.

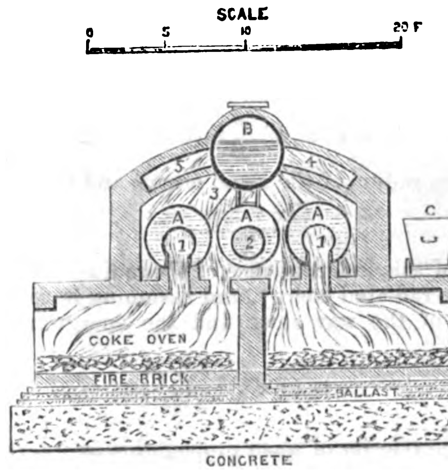
This arrangement of boiler and coke ovens may be at once described. Referring to the diagram on the wall, Fig. 1 is a longitudinal section, and Fig. 2 a transverse section of the combined boiler and coke ovens. In these diagrams, A A^1 A^2 and B represent a form of elephant boiler mounted over a series of twelve coke ovens, the flues from which are arranged with special relation to the flue tubes in the lower parts A of the boiler, and the flue spaces round these and the upper or steam chamber B. The two outer tubular boilers A and A^2 are provided with openings through which the gases enter the flue tube. The gases pass from the coke ovens through these two outer flues in the direction of the arrows and return in the opposite direction through the tube of the central member A^1 of the boiler. They then rise and pass in the direction of the arrows over the tops of A A^1 A^2 and under B. Finally they pass along the flue marked 4 and thence through flue marked 5 to the chimney. The four main parts of the boiler are connected by vertical necks between A^1 and B, and inclined necks between A A^2 and B. At C is shown the position of one of the trucks from which the small coal is fed into the ovens. The diagrams do not show the rising and falling doors by which the coke ovens are closed, nor do they show the details by which the gases from one oven may be for a time directed into the oven next it when the oven has been freshly loaded. These details will, however, be easily understood without description, as will also the similar details by which the greater part of the whole of the gases may be passed to the chimney when steam is not required.



CONCRETE

LONGITUDINAL SECTION

Fig. 1.—Combined Boiler and Coke Ovens for the Economic Generation of Steam.



CONCRETE

CROSS SECTION

Fig. 2.—Combined Boiler and Coke Ovens.

Some particulars will be expected relative to the boiler by which the success of the system has been proved. This

* Paper read before the British Association, Southport Meeting, September, 1883.

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boiler is at the Lea chemical works of the inventor, Mr. Courtenay Kingsford. Its dimensions are as follow:—The boilers A are, length 18ft., diameter 3ft., tube 1ft. 11in.; steam chamber B, length 13ft. 6in., diameter 4ft. 6in. The total heating surface in this boiler is 956 square feet, and of this 644·5 may be taken as effective heating surface. It constantly evaporates about 300 gallons of water per hour. The output of furnace coke from the ovens under this boiler is about 160 tons per month, the product of, say, 266 tons of small coal. This is equivalent to about 8·3 tons, or 19,712lb. of coal coked per day of 24 hours, and as the water evaporated in the same time at the rate of 3,000lb. per hour is 72,000lb., the water evaporated per pound of coke is 3·64lb. Some reduction must, however, be made from this, as the full 3,000lb. of steam is not required at night.

The whole of the coke produced is sold in the immediate neighbourhood of the Lea chemical works, for foundry, cupola, and smithshop purposes, to well-known engineering firms, and as it is a good hard coke the cost of the coal used in generating the steam is recouped. Something might be told of the profit which is possible as resulting from the sale of the coke, but the importance of the system is sufficiently shown, and, moreover, the profit obtainable must be debited with the interest on the cost of ovens, which is somewhat greater than the ordinary boiler setting. It may, however, be mentioned that as the stations for the generation of electricity for lighting or for train or railway purposes must be in or near towns, it is necessary the steam should be generated by smoke-consuming furnaces. For this reason the system described is the best possible, as the whole of the smoke is consumed.

ON THE ENERGY LOST BY RADIATION FROM ALTERNATING ELECTRIC CURRENTS.*

BY PROFESSOR FITZGERALD, F.R.S.

I take the simple case of a small circular current.

The components of the vector potential at any point must satisfy $\Delta^2 F + K\mu \ddot{F} = 0$, while for points very close to the elements of current they must be $F = \mu \frac{n}{v} \delta s$.

Assuming the current simply periodic $c = c_0 \cos 2\pi \frac{t}{T}$, then

$$F = \mu \int \frac{v_0 \cos \frac{2\pi}{T}(t - \sqrt{K\mu}.r)}{r} ds.$$

The energy in any element of the field is per unit volume $= F u + G v + H w$, and as

$$u = -\frac{K}{4\pi} \ddot{F}, \&c.,$$

we can easily represent in the form the square of the above integral the energy per unit volume. Estimating it for the case of a very small circular current, it gives for the energy at any time, on a sphere of radius R,

$$E = (\pi a^2 c_0)^2 \frac{\mu}{6} l^2 (l^2 + R^{-2}),$$

where a is the radius of the small circuit and l is

$$\frac{2\pi \sqrt{K\mu}}{T}.$$

The part of this independence of the radius of the sphere is evidently the radiated energy, and assuming it to move with the velocity of the waves, we find the energy radiated per second

$$e = (\pi a^2 i)^2 \frac{8\mu \pi^4}{3 T^4 v^3},$$

where v is the velocity of wave propagation $= \frac{1}{\sqrt{14}}$.

This is very small indeed, unless the period T be excessively small.

* Paper read before the British Association, Southport Meeting, September, 1883.

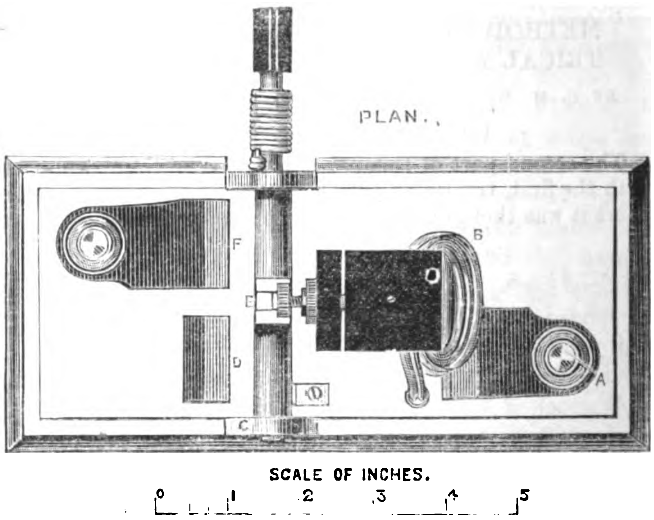
THE INTERNATIONAL ELECTRICAL EXHIBITION AT VIENNA.

(FROM OUR SPECIAL CORRESPONDENT.)

VI.

Returning to the consideration of the Electrical Power and Storage Company's exhibit, we are now able to illustrate Andersen's "cut-out." So much has been said and written about safety-fuses or safety-plugs and the part such apparatus will play in electric lighting, that little need now be added. It seems to be admitted that some form of apparatus must be used to break the circuit when danger of any kind may arise by the passage of too great a current. The danger from too much current is not necessarily that of fire, but may be the destruction of delicate machinery, or the disturbing of delicate mechanism. A fused plug has to be replaced, and

Fig. 1.—Andersen's Cut-out.



FRONT ELEVATION.

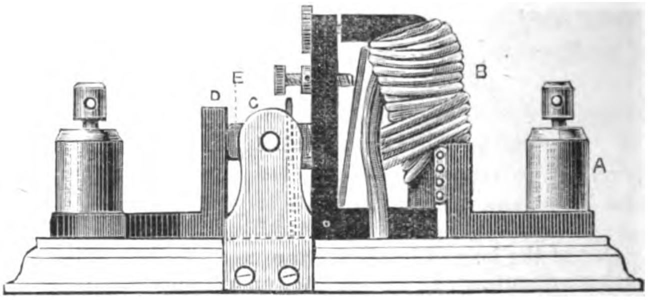


Fig. 2.—Andersen's Cut-out.

we all know what this means. What poor shipwrecked mariner ever looked to find hammer and nails but found gunpowder and bullets? If he wanted a gun nothing in that shape would turn up, and so it is in the world of electric lighting, plugs are always handy when not wanted, but who can say where they are when wanted? Mr. Andersen has a cut-out which can be set to varying degrees of delicacy, and, like a mousetrap, when once it has done duty it may do duty again. The theory of the apparatus is that an electro-magnet, when a current above a certain strength passes through the coil, attracts an armature which is set in opposition to a spring. The motion of the armature releases a contact piece, and this contact piece, actuated by a spring, makes a quarter of a revolution and breaks the circuit. Figs. 1 and 2 show the latest form of the instrument. The current enters at the terminal A, passes in the normal strength through the coil around the core B to the stud D, from the stud D through the contact piece E to the stud F, and to the other terminal. The armature is, as will be seen, opposed to a spring, and the pull of the core upon the armature has to overcome the strength of the spring. As soon as the current renders the core sufficiently powerful the armature is

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attracted, and the contact piece E, which has a slight elbow fitting into a slot in the armature, is released, and under the influence of its spring is pulled through a quarter of a revolution, breaking contact with the armature and both studs, and thus breaking the circuit. The contact piece can be put into position easily enough, but the current only will break the circuit, unless indeed it is wilfully done. The ebonite finger-piece upon the axle of the contact piece of the "cut-out" before us slips round the axle before the contact can be broken, and, having neither sledge hammer nor poker handy, the contact is safe. Adverse critics say springs do not always remain of the same strength, and so, in course of time, the "cut-out" will go off before it is wanted. Better so than not going off when it is wanted. By means of screws the delicacy of the setting can be altered within certain limits as desired.

The excellent exhibit of SCHUCKERT, of Nürnberg, deserves attention. It is one of the largest and one of the best exhibits at Vienna, and speaks well for the energy that this firm has thrown into electrical work. Without treading upon that very dangerous ground as to the first person who suggested 'compound,' machines, it may be mentioned that Mr. Schuckert exhibits several compound machines. These and the ordinary Schuckert machines are indicated by letters and numbers. Thus, the large compound machine illustrated is known as J. L. 6, the smaller compound machine exhibited as J. L. 3, and so on. A peculiarity of the machine illustrated is that the commutator and brushes are inside the framework of the machine. Mr. Schuckert has favoured us with the following interesting details, as well as with certain curves, which will be given in a later letter. The total resistance of the machine is 0·025 ohm, that of the ring armature being ·01 ohm. The thick wire of the magnets has a resistance of ·015 ohm, and the thin wire 32 ohms. The weight of the machine is 2,500 kilogrammes (1 kg. = 2·205lbs.); the length is 1·5 metre (1 m. = 39·38 inches), width 1 metre, and height 1·2 metre. The diameter of the armature is 800mm. The machine (Fig. 3, compound Schuckert) has four pairs of magnets, the arms being 450mm. in length, and 250mm. in diameter. It has been designed to supply current for 350 Edison lamps, and is said to give at 450 revolutions a current of 320 amperes at an E.M.F. of 100 volts. As we may expect the scientific committee at Vienna to test the machines exhibited, and to give us figures similar to those obtained at Munich, it will be as well to leave other figures till the report is given. The theory of the compound dynamo has so recently been discussed by Mr. Kapp (*Electrician*, Vol. X., pp. 114, 154, 200, 232, and 246, that it is not necessary to enter upon it here.

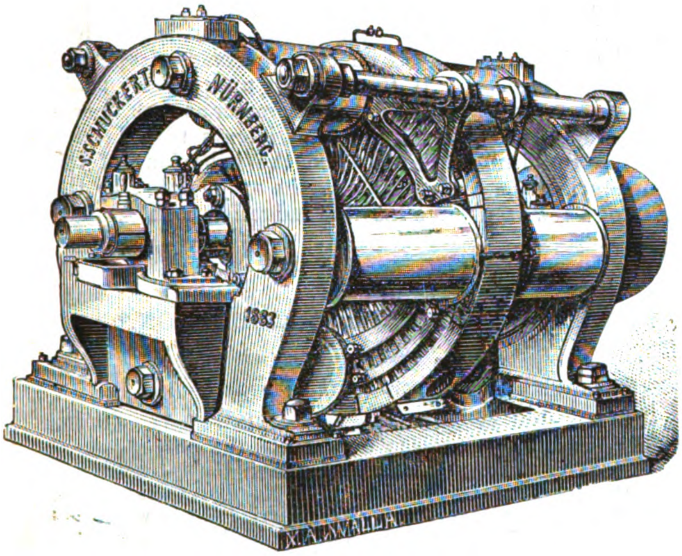

FIG. 3.—Schuckert's Compound Machine, J. L. 6.

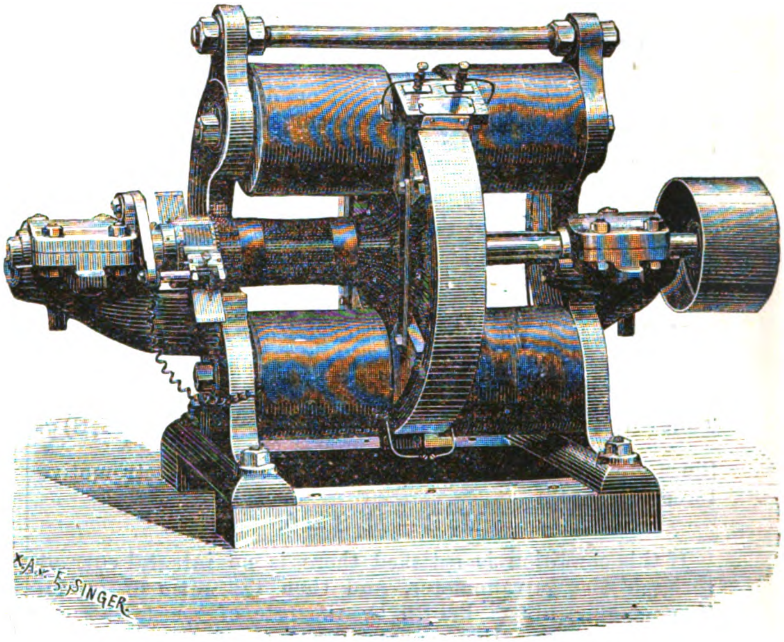

FIG. 4.—Ordinary Schuckert Machine.

Fig. 4 shows one of the ordinary Schuckert machines. The armature is a modification of Pacinotti's ring, and arranged so that the air penetrates freely between the coils in order that heating may be avoided. The electro-magnets are provided with polar extensions almost encircling the armature. The winding is arranged to make the upper polar extensions +, the lower −, the armature of course rotating between the poles. The armature is constructed of a number of sheet iron discs insulated from each other and separated as has been said to allow air passages. Around the ring so constructed is woven the insulated copper wire, in sections similar to the Gramme ring. Each section being connected with the next in order by a wire going to a section of the commutator, that is the end of one section and the beginning of the next meet in the same section of the commutator. Mr. Schuckert claims several advantages for this construction of ring armature over that of the Gramme construction. In the first place it is almost surrounded by the magnets, then the wire discs being insulated from each other and separated owing to the size of the ring, magnetisation and demagnetisation are complete. It is claimed that because of this construction a very high return is obtained for the power applied, and this claim seems to be in accordance with the results of the Munich experiments when the ratio $\frac{L}{A}$ varies from 76 to 92 per cent., acccording to the type of machine and the conditions of the test. A further advantage of the separate coil ring is that the insulation is better, and there is less danger of its failing in work. Attention has been given to the wearing parts of these machines. The shaft rests on long bearings, and the construction is such that the wearing parts may be easily replaced. The wires from the sections are soldered together, and connected to the commutator by screws, so that they can be easily removed, as can the commutator itself from the shaft.

ON A METHOD OF PRODUCING ELECTRO-MAGNETIC DISTURBANCES OF COMPARATIVELY SHORT WAVE.*

BY PROFESSOR FITZGERALD, F.R.S.

This is by utilising the alternating currents produced when an accumulator is discharged through a small resistance. It would be possible to produce waves of as little as 10 metres wave length, or even less.

* Paper read before the British Association, Southport Meeting, Sept., 1883.

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ON THE IMPERFECTION OF THE GALVANOMETER AS A TEST OF THE EVANESCENCE OF A TRANSIENT CURRENT.*

BY LORD RAYLEIGH.

In certain electrical measurements a galvanometer is used to indicate whether or not the integral value of a current of short duration is zero. For example, in the method given in "Maxwell's Electricity," sec. 755, for comparing the co-efficients of mutual induction, M, of two pairs of coils, the evanescence of the integral current through the galvanometer is made the test of the fulfilment of a certain relation between the co-efficients of induction and resistance. The two primary coils are joined up in simple circuit with a battery. The two secondaries are also connected together in such a way that the inductive electromotive forces conspire, and two points, P, Q, one on each connector, are brought into contact with the galvanometer terminals. In special cases, as, for instance, when the two pairs of coils are similar, there is no current through the galvanometer, whatever may happen in the primary circuit; but in general the establishment or interruption of the primary current will cause a deflection of the galvanometer, indicative of the integral value of the current passing. The method consists in adding inductionless resistance coils to one or other of the secondaries until this current vanishes. The required conditions are most readily obtained by supposing the galvanometer circuit broken, and inquiring into the value of the electromotive force E, between the points P and Q. The same current, y, flows in both secondaries, and if x be the primary current, the equations are

$$N \frac{dy}{dt} + M_1 \frac{dx}{dt} + R y = E$$

$$N_2 \frac{dy}{dt} + M_2 \frac{dx}{dt} + S y = - E.$$

M_1 M_2 are the conduction co-efficients to be compared, R S the resistances of the two secondaries (with associated resistance coils), N_1 N_2 their co-efficients of self-induction. Thus $(M_1 + M_2) E = (M_2 N_1 - M_1 N_2) \frac{dy}{dt} + (M_2 R - M_1 S) y.$

Since y begins at 0 and ends at 0, the integral electromotive force vanishes if

$$M_2 R - M_1 S = 0.$$

If this condition is satisfied there is no integral current through the galvanometer, and then the ratio of induction co-efficients is known by the rate of resistance. In general, however, the evanescence of the integral current is obtained by the opposition of consecutive positive and negative parts, and even although the whole duration of the effect is but a small fraction of the time of vibration, the needle of the galvanometer will be disturbed in such a manner as to make it difficult to say whether or not the whole impulse acting upon it be zero. To obtain a satisfactory measurement, it is necessary to secure at least an approximate fulfilment of the second condition required in order that the current may be zero throughout, viz.,

$$M_2 N_1 - M_1 N_2 = 0.$$

In this there is no difficulty, as we can easily increase the defective self-induction by the addition of other coils placed at a sufficient distance. The most convenient plan is to induce two coils by the variations of the relative situation of which the self-induction can be adjusted. With moderate care the initial impulsive electromotive force caused by a sudden variation of the primary current, and dependent only upon the induction co-efficients, may be made so small that the needle shows no uneasiness when the other adjustment relative to the resistances is complete.

In March, 1881, I attempted, in conjunction with Messrs. Glazebrook and Dodds, to carry out the plan above suggested for the comparison of two co-efficients of mutual induction. No satisfactory result could be obtained in the ordinary method of working, the needle showing uneasiness whatever resistances were employed, so that it was impossible to fix upon any particular value as corresponding to a zero integral current. The addition of other coils to increase the self-induction of one of the secondaries was so far successful that the needle could be reduced to quietness, but calculations showed that the additional self-induction found to be necessary in experiment was much in excess of what the above theory would indicate. The explanation which afterwards suggested itself to me was that the anomalous effect was due to the conducting rings upon which some of the coils were unwound, and whose presence complicates the otherwise simple theory. We verified this view by bringing a coil of wire into the neighbourhood of one of the principal coils, the behaviour of the galvanometer needle being very sensibly different according as the auxiliary coil was open or closed. The kind of embarrassment to which measurements of the kind are subject is well illustrated by placing the galvanometer in a tertiary circuit, not directly influenced at all by the battery current in the primary. A pair of coils with double wires, such as are often used for large electro-magnets, are suitable for the experiment. One wire of the first coil is connected with the battery and forms the primary circuit. The second wire of the first coil and the first wire of the second coil are connected and constitute together the secondary circuit. The second wire of the second coil and the galvanometer form the tertiary circuit. The apparatus must be so adjusted that no effect is perceived at the galvanometer when the secondary is broken, whatever may happen in the primary. When their adjustment is complete the secondary is closed and the effect is observed of opening or closing the primary. If the contacts are properly made the integral current through the galvanometer at each operation is rigorously zero, but in the experiments that I have made no one could infer the fact from the behaviour of the galvanometer needle. The effect may be exaggerated by the insertion of a few iron wires into the induction coils.

* Paper read before the British Association, Southport Meeting, September, 1883.

THE MUNICH ELECTRICAL EXHIBITION.*

The Committee's Report on the Lamps Shown.

The photometrical measurements were of two kinds. On the one hand relative measurements were made, the only object of which was to compare the relation between the intensities of light emitted by the same lamp in different directions; on the other hand absolute measurements were carried out in which not only the intensity of each lamp was determined in candles, but also the relation between this intensity and the electrical and mechanical work expended. We will deal with these two methods in order, first as concerns the incandescent lamps, and then the arc lamps :—

Incandescent Lamps.

For the relative measurements each incandescent lamp was first of all dealt with in the photometer in a vertical position, the plane of its filament being perpendicular to the slit of the apparatus, this position being taken as zero. Then the lamp was rotated on its vertical axis at different intervals, each forming an angle of 22·5°, until it returned to its original position, a photometric measurement being taken at each new position. This done the lamp was rotated from 22·5° to 22·5° round a horizontal axis, taking as zero its original position in the above mentioned experiment, and as 90° the position in which the lamp became horizontal, the top of the globe being turned towards the photometer. During these measurements comparison was made, not with any photometrical standard, but with a second lamp similar to the first and fed by the same current. The intensities of light emitted in different directions were calculated from the figures obtained, taking as unity the intensity given in the zero position, that is, when the plane of the filament is perpendicular to the slit of the photometer. These intensities will be found in Table I.

It will be remarked on looking at the table that the intensity at 0°, which should, after what we have just said, always be 1, often differs by a small quantity; this is owing to the fact that in the majority of cases three observations were first made (at 0°,

* From *La Lumière Electrique*, for September 15, 1883.

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180°, and 360°) and the arithmetical mean of these three observations taken as unity.

By the aid of the figures contained in the table graphic diagrams have been enabled to be constructed representing the intensities of light emitted by each lamp in the horizontal and vertical plane. To do this a circle, with radii at 22·5° distance, has been

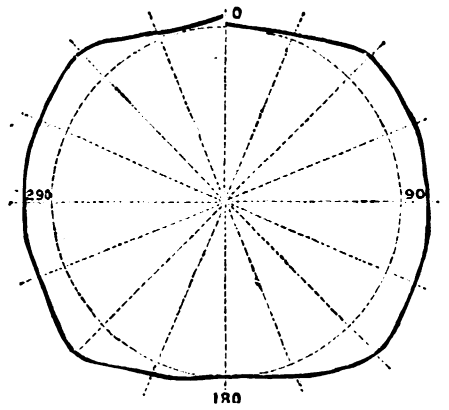

Fig. 1.—Diagram of Edison A Lamp in horizontal plane.

drawn. The length of the radius having been taken as unity, in each radius a length corresponding to the intensity obtained at the angle where this radius is situate is set off, and in this way a continuous curve has been obtained, representing the intensities emitted in the plane under consideration.

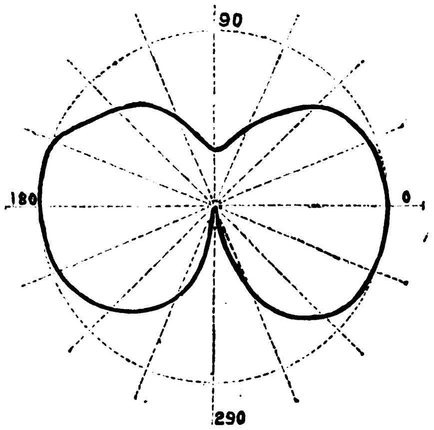

Fig. 2.—Diagram of Edison A Lamp in vertical plane.

For the vertical plane, in which observations were made from 0° to 90° only, the same intensities were obtained as far as 45° below the horizontal as above, for in diametrically opposite directions the projection of the filament is the same. From 67·5° below the horizontal the radiation decreases very quickly,

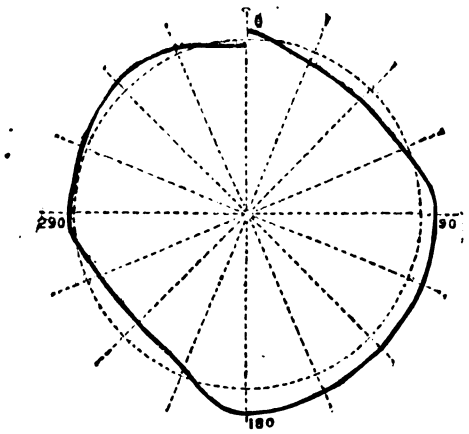

Fig. 3.—Diagram of Swan Lamp in horizontal plane.

because it is completely stopped by the support of the lamp. We give herewith some of the curves obtained in this way.

Fig. 1 represents the intensities emitted by the Edison A lamp in the horizontal plane. Fig. 2 the same in the vertical plane. For the Edison B lamp the general character of the curve is identical.

Fig. 3 gives a diagram of the intensities emitted in the horizontal plane by the Swan No. 1 lamp, and Fig. 4 the same for the same lamp in the vertical plane.

Fig. 5 is the diagram of a Maxim No. 1 lamp in the horizontal plane, and Fig. 6 a diagram of the same lamp in the vertical plane. The Swan No. 5 lamp and the Maxim No. 3 give curves

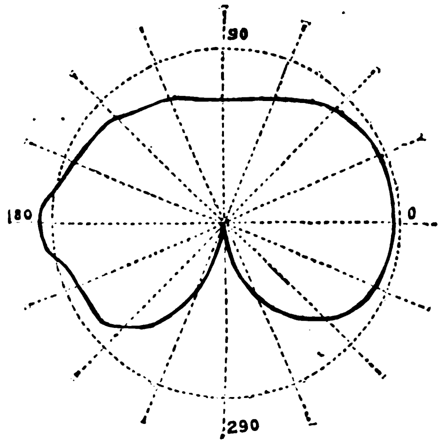

Fig. 4.—Diagram of Swan Lamp in vertical plane.

which differ but little from those of the two preceding lamps. For Cruto's and Muller's lamps the curve in the horizontal plane is almost identical with the circumference of the diagram,

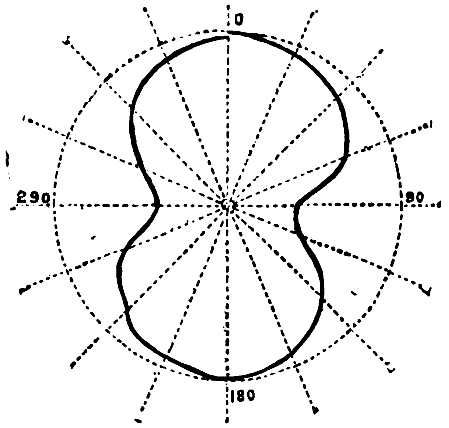

Fig. 5.—Diagram of Maxim Lamp in horizontal plane.

and the diagram representing the vertical plane has the same contour as that of the Swan lamp.

Having stated these results, Dr. E. Voit, who has edited this

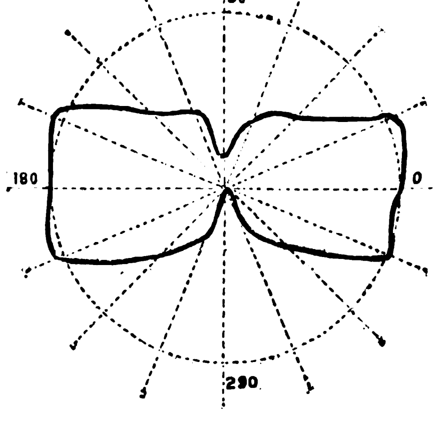

Fig. 6.—Diagram of Maxim Lamp in vertical plane.

part of the report in a remarkably able manner, offers the following remarks :—

The light of incandescent lamps being emitted by carbon at a red heat, that is by an opaque body, we may take as a basis for calculation the well-known law of Lambert. According to this law the quantity of light which falls from an element of luminous

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surface df, (Fig. 7), on a lighted element df' is represented by the formula

$$q = \frac{i\,df\,df'\cos e\cos e'}{r^2},$$

in which i represents the luminous power of the element df, r the distance between df and df', e and e' the angles which the line makes that joins the elements with the normals at their surface. According to this, the quantity of light that a surface, all of whose elements are of equal intensity i, normally projects on an element df' placed at a great distance r is represented by

$$Q = \frac{i\,df'}{r^2}\int \cos e\,df \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

Where the integral extends to the whole lighting surface.

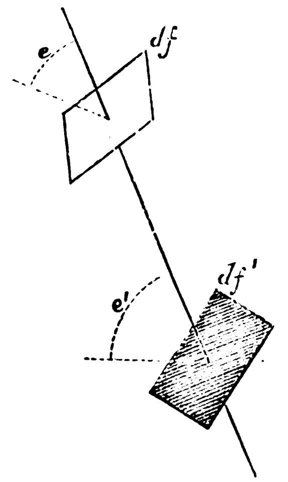

Fig. 7.

The hypotheses upon which this formula are established are well in accord with the case of incandescent lamps; in point of fact when the filament is homogeneous, the same quantity of heat is produced throughout it, and consequently the same luminous radiation i. The agreement between the values theoretically obtained and those afforded by practice will therefore confirm the homogeneity of the filament. On the other hand, in

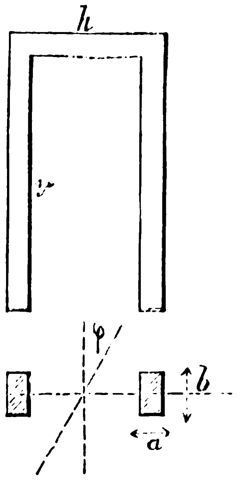

Fig. 8.

the photometrical measurements, the distance r is very great by comparison with the dimensions of the lighting body; in the Edison lamps, for instance, the greatest length of filament is 65mm., whilst r amounts to 1·50m. at the least.

Formula (1) also leads us to this law, that for a luminous lighting body the quantity of light emitted in a given direction is proportional to the projection of the body on a plane perpendicular to the direction of the radiation. We will apply this law to the distribution of the light emitted both in horizontal and vertical planes by a carbon filament of simple form. Let us suppose that the carbon filament has a quadrangular section, and, to obtain greater simplicity in the calculations, let us suppose that the filament has sharp angles, and is composed of two vertical rods connected by a horizontal one. We will call v (Fig. 8) the length of one of the vertical rods, h that of the horizontal one. We will also call a and b the sides of the rectangular section, b being the side perpendicular to the plane of the filament. The angle which the direction of the rays makes, with the surface perpendicular to the plane of the filament, we will term ϕ. According to formula (1), the quantity of light sent in the direction ϕ on the element of surface df' is

$$Q = \frac{idf'}{r^2}\left[2v\,(a\cos\phi + b\sin\phi) + ha\cos\phi\right]. \quad . \quad . \quad . \quad (2)$$

From this we at once get

$$\phi = 0^\circ,\ Q^1 = \frac{idf'}{r^2}\,(2\,va + ha) \quad . \quad . \quad . \quad . \quad . \quad . \quad (2a)$$

$$\phi = 45^\circ,\ Q^2 = \frac{idf'}{r^2}\left(\frac{2va + 2\,vb + ha}{\sqrt{2}}\right) \quad . \quad . \quad (2b)$$

$$\phi = 90^\circ,\ Q^3 = \frac{idf'}{r^2}\,(2\,vb) \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (2c)$$

and further, we get the total quantity of light emitted by the lighting body in the horizontal plane, as—

$$Q' = \frac{4\,idf'}{r^2}\int_0^{\frac{\pi}{2}}\left(2\,v\,[a\cos\phi + b\sin\phi] + ha\cos\phi\right)d\phi \quad . \quad (3)$$

If we call the mean horizontal intensity J h, that is the intensity the lighting body would possess in one direction, if it emitted the same quantity of light, but equally in all horizontal directions, we then have

$$J\,h = \frac{\frac{idf'}{r^2}\int_0^{\frac{\pi}{2}}\left(2\,v\,(a\cos\phi + b\sin\phi) + ha\cos\phi\right)d\phi}{\frac{4\,df'}{r^2}\int_0^{\frac{\pi}{2}}d\phi}.$$

or

$$J\,h = i\,\frac{2\,(2\,v\,a + 2\,vb + ha)}{\pi},$$

and

$$Q\,h = J\,h\,\frac{df'}{r^2} = \frac{idf'}{r^2}\,\frac{2\,(2\,va + 2\,vb + ha)}{\pi} \quad . \quad . \quad . \quad (4)$$

If we divide this latter value of the mean horizontal intensity by the quantity of light emitted at an angle of 45°, we have

$$\frac{Q\,h}{Q^2} = \frac{2\sqrt{2}}{\pi}\,\frac{(2\,va + 2\,vb + ha)}{(2\,va + 2\,vb + ha)} = \frac{2\sqrt{2}}{\pi} = \cdot 9003 \quad . \quad . \quad (5)$$

If we call this relation the theoretical co-efficient of reduction, formula 5 will lead us to the following interesting result:—

The theoretical co-efficient of reduction is constant; it is, moreover, independent of the dimensions of the filament, and consequently of the values a, b, v, and h. We will now compare one of our calculations with the observations made on the lamps corresponding to our hypotheses, amongst which lamps must be reckoned the Edison, and also, as we shall see later on, the Maxim.

The mean horizontal intensity, which must be known in order to calculate the co-efficient of reduction, is obtained by taking the arithmetical mean of the intensities measured at different angles in the horizontal plane. It will be understood that the exactness of this value will be greater as the angle which divides two consecutive observations becomes smaller. Professor Hagenbach, moreover, ascertained for certain, by a preliminary experiment, that the mean obtained between 22·5° and 22·5° is very near to the mean

$$\frac{\text{Direction } 0^\circ + 2 \times \text{direction } 45^\circ + \text{direction } 90^\circ}{4}.$$

Further, Professor Hagenbach measured the intensities at 0°, 45°, and 90°, given by 8 Edison lamps, large and small, the mean horizontal intensity was deduced, and the relation of this latter to the intensity at 45° determined. This relation he has called the empirical co-efficient of reduction, and it should coincide with the theoretical co-efficient of reduction if the supposed conditions of the calculation are realised.

Experin nt has given the empirical co-efficient of reduction for Edison lamps as ·95, the theoretical co-efficient being ·90. This is evidently due to the fact that the section of the filament is not perfectly rectangular, but rounded at the angles. This experiment means no more than that, for Edison lamps, we can find the mean horizontal intensity by multiplying the intensity at 45° by the empirical co-efficient ·95. This law may be extended to all other lamps in which the filament has a sensibly rectangular section, as in the Maxim lamp. The empirical co-efficients of reduction for two types of this lamp have been found to be ·95 and ·97.

For lamps with filaments of circular section the projection is

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TABLE I.—INTENTSITIES OF LIGHT EMITTED BY INCANDESCENT LAMPS AT VARIOUS ANGLES.

Rotated Round an Axis	0°	22·5°	45°	67·5°	90°	112·5°	135°	157·5°	180°	202·5°	225°	247·5°	270°	292·5°	315°	337·5°	360°
									MEDIUM SIZE MULLER LAMP, No. 1.								
Vertical	1·043	1·038	1·043	1·015	1·016	1·030	1·023	1·011	1·031	1·031	1·020	·999	·963	·965	·959	·982	1·000
Horizontal	·985	·951	·850	·707	·810	...	...	...	...	...	...	...	...	...	...	...	·971
									LARGE SIZE MULLER LAMP, No. 1.								
Vertical	·997	...	·956	...	·980	...	·995	...	·994	...	·964	...	1·008	...	1·020	...	·992
Horizontal	·992	1·003	·872	·886	·831	...	...	...	...	...	...	...	...	...	...	...	...
									CRUTO LAMP, No. 1.								
Vertical	1·076	...	1·027	...	·947	...	·935	...	·946	...	·961	...	·929	...	·988	...	·987
Horizontal	·987	...	·935	...	·724	...	...	...	...	...	...	...	...	...	...	...	...
									MAXIM LAMP, No. 1.								
Vertical	1·002	·972	·837	·733	·403	·564	·710	·925	·932	·936	·876	·862	·303	·543	·764	·870	·998
	1·007	·936	·807	·591	·370	·423	·733	·935	1·004	·924	·856	·471	·524	·522	·862	·935	·997
Horizontal	·997	6·985*	·536	·528	·125	...	...	...	...	...	...	...	...	...	...	...	...
	...	1·046	·549	·443	·201	...	...	...	...	...	...	...	...	...	...	...	...
	...	1·045	·601	·400	...	...	...	...	...	...	...	...	...	...	...	...	...
									MAXIM LAMP, No. 2.								
Vertical	·997	·895	·741	·421	·330	...	·709	·944	1·011	...	·915	...	·337	...	·750	...	1·009
Horizontal	·993	·941	·563	·476	·101	...	...	...	...	...	...	...	...	...	...	...	...
	·996	·949	·609	·492	·109	...	...	...	...	...	...	...	...	...	...	...	...
									SWAN LAMP, No. 1.								
Vertical	1·010	·905	·890	·980	·664	1·077	1·093	1·101	1·025	·951	·927	·950	1·023	1·027	1·068	1·038	·959
Horizontal	·988	·954	·867	·745	·652	·721	·841	·929	1·042	...	...	...	...	...	...	...	...
									SWAN LAMP, No. 2.								
Vertical	1·016	1·073	1·020	1·001	1·054	1·029	·958	·904	1·021	1·089	1·032	·992	1·082	1·033	·958	·899	·997
Horizontal	·997	·957	·887	·783	·815	...	...	...	...	...	...	...	...	...	...	...	·990
									EDISON A LAMP, No. 1.								
Vertical	·988	1·014	1·199	1·195	1·201	1·209	1·175	1·009	·965	1·053	1·165	1·176	1·163	1·166	1·126	1·218	1·047
Horizontal	1·000	·935	·809	·540	·320	...	...	...	...	...	...	...	...	...	...	...	...
									EDISON B LAMP, No. 2.								
Vertical	·999	1·261	1·346	1·404	1·462	1·391	1·389	1·139	1·025	1·142	1·334	1·376	1·317	1·384	1·301	1·032	·920
Horizontal	1·056	·417	·808	·708	·137	...	...	...	...	...	...	...	...	...	...	...	...

* Query ·985. Translator.

the same in every way, and the quantity of light emitted is, as we have seen, the same in all directions; there is, therefore, no longer any need of the co-efficient of reduction. In the Swan lamp the section appears to be oval. The mean horizontal intensity can, as will be seen from equations 2 and 4, be ex-

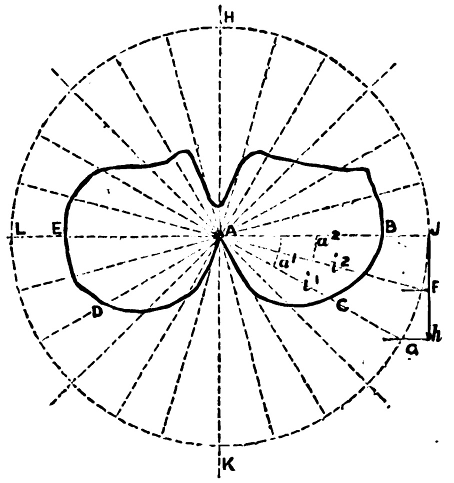

FIG. 9.

pressed as a function of the intensity i° in the position 0°, it is therefore

$$Jh = Ci^{\circ},$$

in which C is a constant depending on the dimensions of the lamp, and which Dr. Voit calls the co-efficient of reduction of the mean horizontal intensity.

In calculating by means of formulæ analogous to those given above the intensities emitted in a vertical plane at different angles with the horizon, a very satisfactory similarity of result has been found with intensities obtained at these angles.

But the intensity of the greatest importance is the mean spherical intensity (*mittlere ræumliche Intensitæt*).

The committee determined this by supposing that the distribution of intensities found for a given horizontal plane was reproduced in all planes parallel to this latter, and by constructing by interpolation the curve of intensities in a vertical plane corresponding to the position of the lamp at 0°. The mean spherical intensity is thus calculated :—

If from the luminous point A (Fig. 9) equal intensities J are radiated in all directions (the mean spherical intensity), the quantity of light sent on the element of surface df' of a sphere of radius r and centre A is $i\,df'$; the total quantity of light emitted is

$$M = 4 \pi r^2 J.$$

If, on the other hand, the light emitted by A is not the same in all directions, the quantity of light falling on the zone FG can be determined by supposing that the intensity in this zone is constant, and expressed by $\frac{i' + i''}{2}$, i' and i'' representing the intensities radiated at the angles a^1 and a^2. The liability to error will naturally be less the nearer a^1 is to a^2. The quantity of light, therefore, falling on the whole of the zone FG is :—

$$2 \pi r h \frac{i' + i''}{2} = 2 \pi r^2 (\sin a^1 - \sin a^2) \frac{i' + i''}{2},$$

and the total quantity of light falling on the whole surface of the sphere

$$M^1 = \frac{2 \pi r^2}{2} \Sigma (\sin a^1 - \sin a^2) (i' + i''),$$

the sum applying to the whole of the half circle H J K; but M^1 should be equal to M, we therefore have

$$4 \pi r^2 J = \pi r^2 \Sigma (\sin a^1 - \sin a^2) (i' + i''),$$

whence,

$$J = \frac{1}{4} \Sigma (\sin a^1 - \sin a^2) (i' + i'').$$

The quantities i' and i'' are the mean intensities falling on the different parallels, which we get, in accordance with formula 5,

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TABLE II.—RESULTS OF TESTS OF INCANDESCENT LAMPS AT MUNICH AND PARIS.

Lamps.	Mean spherical luminous intensity in normal candles.	Resistance hot in ohms.	Difference of potential in volts.	Current in amperes.	Electrical work in		Mean spherical intensity per h.-p.	No. of lamps per h.-p.
					Volt amperes.	H.-P.		
RESULTS OBTAINED BY THE MUNICH COMMITTEE.								
Edison B	11·69	67·68	55·78	·825	46·02	·0625	186·90	23·36 (8 candles)
Ditto A	15·32	139·60	103·05	·755	77·80	·1057	144·83	9·05 (16 „)
Maxim	13·34	47·01	65·07	1·384	90·06	·1224	103·98	3·89 (28 „)
Swan A	10·95	31·91	38·38	1·222	46·90	·0637	171·78	17·18 (10 „)
Ditto B	37·17	87·03	118·02	1·282	151·30	·2056	180·75	4·52 (40 „)
Siemens	14·90	104·72	95·74	·915	87·60	·1191	125·14	7·82 (16 „)
Muller A	18·43	58·62	74·04	1·263	93·51	·1271	145·01	7·26 (20 „)
Ditto B	43·08	59·52	105·22	1·779	187·19	·2544	169·33	3·39 (50 „)
Ditto C	102·35	65·41	155·15	2·367	367·24	·4991	205·05	2·05 (100 „)
Cruto	8·47	8·16	22·15	2·715	60·14	·0817	103·58	10·36 (10 „)
RESULTS OBTAINED BY THE COMMITTEE OF THE 1881 EXHIBITION.								
Edison A	15·38	137·4	89·11	·6510	57·93	·0783	196·4	12·28 (16 candles)
Ditto C	31·11	130·03	98·39	·7585	74·62	·0941	307·25	9·60 (32 „)
Swan A	16·61	32·78	47·30	1·471	69·24	·0945	177·92	11·12 (16 „)
Ditto B	33·21	31·75	54·21	1·753	94·83	·1059	262·49	8·20 (32 „)
Lane-Fox A	16·36	27·40	43·63	1·593	69·53	·1025	173·58	10·85 (16 „)
Ditto B	32·71	26·59	48·22	1·815	87·65	·1289	276·89	8·65 (32 „)
Maxim A	15·96	41·11	56·49	1·380	70·85	·1191	151·27	9·45 (16 „)
Ditto B	31·93	39·60	62·27	1·578	93·41	·1337	239·41	7·48 (32 „)

by multiplying the intensity directly observed in this direction by the co-efficient C. If, then, the intensities observed be i^1 and i^2, we have

$$J = \frac{C}{4}\,\Sigma\,(\sin a^1 - \sin a^2)\,(i^1 + i^2),$$

or lastly

$$J = C^1\, i^0,$$

a formula in which C^1 may be called the co-efficient of reduction of the mean spherical intensity. When i^0, the intensity of the lamp at position 0°, is taken as unity, we have $J = C^1$.

The co-efficients of reduction C^1 for the different lamps were calculated by the aid of these formulæ and the observations reported above, and from these the mean spherical intensities could be obtained. These co-efficients were as follow :—

Lamps.	Co-efficients.
Edison A	·971
Ditto B	1·054
Maxim No. 1	·598
Ditto No. 2	·577
Swan No. 1	·828
Ditto No. 5	·844
Muller (medium)	·828
Ditto (large)	·854
Cruto No. 1	·769

For absolute measurements they were obtained by taking count each time of the electrical data. The table given below (Table II.) gives the mean of numerous observations, and gives, for sake of comparison, the results obtained by the committee of the exhibition in 1881.

In addition to these results Dr. Voit endeavoured to utilise the very numerous observations made to study the relation between the luminous intensity and the work expended in the lamp.

It will be remembered that Mr. Jamieson plotted curves for several incandescent lamps by taking as abscissæ the quantities of work expended, and as ordinates the luminous intensities. Dr. Voit has represented them by a simple analytical formula, and he has ascertained that the luminous intensity increases as the cube of the work expended. Mr. Jamieson's curves were produced by means of the formula

$$L = a\,(a)^3$$

in which L represents the luminous intensity, a the work available in the lamp, and a a co-efficient which represents the luminous intensity produced by unit work (kilogrammetre) in the lamp.

According to the observations of Mr. Jamieson the value of this co-efficient for the undermentioned lamps was as follows :—

Lamps.	Co-efficients.
Edison 7 B	·000 136
British Electric Light Co.'s No. 3	·000 116
Lane-Fox	·000 098
Swan No. 1	·000 073
Maxim	·000 066
Swan No. 11 (with ground glass)	·000 042

Passing now to the observations made at Munich, M. Voit endeavoured to find by the method of least squares which of the three expressions $a(a)^2$, $a(a)^3$, $a(a)^4$, for the luminous intensity was in accordance with the observations, and he found that the formula $L = a(a)^3$ was most in accord with the results of tests.

In constructing curves by means of this formula and comparing them with those obtained from observations, we find that errors in experimenting in some cases reach a high figure, but that generally speaking the agreement is satisfactory. An exception must, however, be made in the Cruto lamp, for which the formula $a(a)^2$ gave better results. The reason of this probably lies in an anomaly in this lamp. In other lamps the resistance when hot diminishes as the current increases; in the Cruto lamp, on the contrary, it increases with the current.

Dr. Voit proposes, therefore, to provisionally adopt the formula $L = a(a)^3$ as sufficiently exact within the limits of the observations, that is for lamps of 16 to 120 candles, and to take the co-efficients a as an expression of the practical value of incandescent lamps, since they represent the quantities of light emitted by the lamps in their normal position per unit of available work. These co-efficients must, however, be corrected to represent the mean spherical intensity emitted per unit of work in the lamp. Their mean is therefore :—

Lamps.	Co-efficients.
Edison A	·0000 376
Edison B	·0001 106
Swan (small)	·0000 848
Swan (large)	·0000 096
Maxim	·0000 148
Siemens	·0000 225
Muller (small)	·0000 213
Muller (medium)	·0000 067
Muller (large)	·0000 021
Cruto	·0000 250

The numerous observations made with incandescent lamps lead, therefore, to an interesting result, and have, moreover, permitted the laying down of the two following laws :—

1. The intensities emitted by an incandescent lamp in the horizontal plane in different directions depend upon the section of the filament; if the latter be circular in section it causes an equal intensity to be emitted in all directions in a horizontal plane.

2. The light emitted in a given direction by an incandescent lamp is dependent upon the projection of the filament in this direction.

ON PATENTS FOR INCANDESCENT LAMPS.

BY C. A. STEPHENSON.

Any one who takes the trouble to look through the earlier patents for incandescent lamps will be very apt to declare that there is no new thing under the sun, but a closer examination will show that, whilst the main principles are old, there are many new points of detail that have in reality only been invented of late years, and for which patents have been obtained.

The earliest patent is that of Edw. Aug. King (No. 10,919 of 1845). He describes an incandescent lamp with a filament of

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platinum, and he appears to have thought a carbon filament as quite a secondary consideration. In the specification he says :—"When carbon is used it becomes necessary, on account of the affinity this substance has for oxygen at high temperature, to exclude from it air and moisture. To accomplish this in the most perfect manner it should be enclosed in a Torricelian vacuum. . . . . That form of carbon found in the interior of coal gas retorts which have long been used is well suited for the purpose."

The filament was a thin straight strip, and the details of clamps, &c., appear very clumsy compared with our modern lamps, but, be it remembered, this invention is nearly forty years old.

Mr. W. E. Staite, in Patent 12,212 of 1848, is the first to give the horseshoe form to a filament. His lamp is an incandescent one, but not burning in vacuum; the filaments are made of prepared irridium, but he also prepares electrodes from plumbago powder, prepared by washing and warming in acids; also from lampblack, charcoal powder of sundry kinds of wood, carbon of gas retort, mixed with sugar, &c. Like King, Staite seems to have thought the carbon filament inferior to a metallic one, and only worthy of secondary consideration. In the same year Alex. Ed. Le Molt, in Patent No. 12,219, describes an arc lamp for which the carbons, after being cut to the form required, are "purified by being immersed in a solution of nitric and muriatic acid for about twelve hours."

In patent No. 13,302 of 1850, Mr. E. Clarence Shepard describes a lamp consisting of "a cylinder of charcoal" in vacuum, which is kept continually pressed down as it burns away.

In Patent 14,198 of 1852, Mr. Martyn John Roberts gives a graphic description of an incandescent lamp. He says: "Another part of my invention consists of a mode of obtaining electric light by passing a current of electricity through a thin piece of graphite, coke, or charcoal, or other infusible body being a conductor of electricity while it is enclosed in a vacuum or space not containing any oxygen. . . . I claim the production of light by passing electricity through a thin infusible body being a conductor of electricity in the manner before described."

Finally, Mr. S. W. Konn, in 1872, took out a patent, No. 3809, which is now void. He describes an incandescent lamp with a filament of carbon or graphite burning in a globe filled with nitrogen, or other gas that does not support combustion.

This closes the list of patents till we come to the present era, beginning in 1878. All the foregoing patents are now void, and it will be well here to summarise their contents, bearing in mind that, although patents similar to the above may again have been taken out, such patents will be found to be worthless.

From the foregoing it is clear that a vacuum incandescent lamp can be made with a filament of any of the following materials—carbon, the carbon of gas retorts, charcoal, graphite, a thin infusible body, and coke. There can be no doubt that these words would cover the use of every conceivable material from which carbons could be made; but up to this time little progress had been made in the mode of preparing carbons. The use of nitric and muriatic acid for cleansing carbon was known, as also was the horseshoe form of carbon which is so generally supposed to be modern. Turning from carbon to metal filaments, it is curious to note how the use of platinum and irridium was reinvented after a lapse of years, to be abandoned in favour of carbon, which, owing to its present superiority in manufacture, and to the better vacuums that can now be procured, is not likely again to give way to metal.

I propose now from the beginning of 1878 to the end of 1880, to deal, in strict chronological order, with those patents only in which a novelty exists that up to the present time has not become obsolete. In this way I shall be able to show, step by step, how invention has proceeded, and who are the patentees of the various processes with which the scientific world has now become familiar.

I have already stated that a carbon filament could be made from any conceivable material, and that no patent for the material itself would hold good. Before dismissing this point I will show that inventors themselves were of the same opinion in the year 1878. Mr. Sawyer, in Patent 4847 of that year (a patent by the way which has escaped the notice of the far-searching Mr. Dredge in his most valuable work), makes the following broad statement:—"At the present day it is not new to produce a light by causing the electric current to heat a carbon conductor to incandescence in a vacuum, or in nitrogen or other gas."

The first complete patent for the year 1878 was that of Mr. St. George Lane-Fox, No. 3988. There is nothing in the claim which is now of any substantial value; but a new principle is evolved, namely, that of high resistances, so high that it was expected that the lamps would be lit by a current of 100 volts E.M.F.

Moulds for Carbon Filaments.

Mr. E. G. Brewer, in Patent No. 4502 of 1878, describes a process of preparing filaments by moulding finely divided metals and earthy material, and pressing them into shape. A somewhat similar process is described by Mr. Grey in patent 4553 of the same year (now void). The material used is powdered carbon, washed in acid or alkaline, and after moulding the carbons are dipped in boiled sugar or molasses and reheated.

Mr. Edison, however, was the first to patent the use of a mould for a whole substance. In Patent No. 5127 of 1879 he describes and claims "a method of manufacturing carbons . . . consisting in exposing the filament of paper to the action of heat in a mould, to drive off the volatile portions, and carbonise the paper."

(TO BE CONTINUED.)

THE JABLOCHKOFF ELECTRIC LIGHT AND POWER COMPANY (LIMITED).

The ordinary annual general meeting of this Company was held on the 4th inst., at the City Terminus Hotel, under the presidency of James Wilson, Esq.

The SECRETARY and GENERAL MANAGER Mr. Francis R. Reeves) having read the notice convening the meeting,

The CHAIRMAN said: Gentlemen, the report, as you see, states pretty fully what we have been doing since the Company was launched fifteen months ago. It tells you that the Embankment light has been proceeding from the time we took it over, but the contract was made at an unfortunate time, and it has proved a losing concern, as you all know. But it forms a capital advertisement for our business. It was supposed it would at least pay its working expenses, but it does not. There had been an annual loss upon it of £700 a year when we took it, but it has been reduced to about £500. Soon after the formation of the Company, and finding the time for forming subsidiary companies had passed for the moment, we turned our attention to the actual establishment of a factory, and to carrying out installations throughout the whole country and abroad. You will recollect that the purchase of our patent is not merely for the metropolis, or for England, but for the whole of the British Isles and the colonies, with the exception of India. At the time of the contract we had to purchase all our candles, which are the backbone and foundation of the Company. We had to purchase them in Paris, but after that we acquired machinery which had been constructed in Paris for this purpose, and also Frenchmen who were accustomed to make the candles, and we took premises, and now we manufacture them for ourselves, and that forms an excellent source of profit. We are making them better and cheaper than those supplied by the French Company. The works are well worth a visit, and as any shareholder can obtain an order from the secretary, you will be able to see that the business of the company is placed upon an established footing for the manufacture of the Jablochkoff candles, of which we are making thousands upon thousands at a profit. We have electricians to carry on installations not only in London, such as the Covent Garden Theatre, the Avenue Theatre, and other places, but also in the provinces. In the first instance, there was not much profit attached to these; but we are now enabled to work at a decrease of expenditure and an increase of profit in the undertaking. We are also working at Belvedere Works, Lambeth, which are supplied by an engine which was taken over at the time of the formation of the company. The wires are carried across Waterloo Bridge, and supply the lights for the Covent Garden Theatre and the Gaiety Restaurant. We had hopes that this engine would have done much more work by now, but we have been, in a measure, paralysed by the "powers which be." We hope something may come in the future, although we have to rest a short time before we take any steps. I refer to the course adopted by the Board of Trade. They seemed to say to the parishes—It is useless to shut your eyes as to the importance of this future light, and however great your interest, individually or collectively, may be in gas, we are determined that you shall not stand still, and that you shall have this light. Therefore we tell you you may adopt any system you please; we leave you any system you like; adopt it yourselves; we will enable you to grant licenses for seven years to any parties you please, but should you not do so, and in your apathy or ignorance refrain from taking such a course, we will step in and grant provisional orders to whomsoever we like for twenty-one years (which really means in perpetuity). Well, we succeeded against great opposition in actually obtaining from the Strand Board of Works licenses for the whole of their large district, which comprises six parishes, and with these in our hand we certainly thought we had succeeded in establishing in the largest district in the metropolis a great and important business, which would compel us in that one parish to spend from £70,000 to £80,000 in plant and installations. We also obtained licenses from the vestry of Marylebone, where also an equal amount had to be spent, and having these in hand, and seeing that our capital was small, one-third having yet to be issued, I obtained an introduction to a member of one of the leading houses in the City, and he said to me, in the presence of our secretary:—"Mr. Wilson, if you get those licenses confirmed by the Board of Trade we will find you as much money as ever you like." However, in the result I may tell you, as no doubt you all know, the Board of Trade, in opposition to the Strand Board, have granted to the Edison and Swan Company provisional orders for the whole of those six parishes. We contested that both in the House of Lords and the House of Commons, and the House of Lords I may tell you, from what I have heard, were actually in our favour, but the Board of Trade officials seemed to have sided most strongly with the Edison and Swan Company against the wishes of the vestries, and gave to the Edison and Swan Company the provisional orders for twenty-

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one years for the whole of those six parishes. We do not know at present what to do in the matter: but supposing we can go on, and have sufficient funds, we hope to be enabled to make arrangements in your interests. We are sure, and so are the parishes, that our arc light is the one that will outlive all the others. We have shown at various exhibitions, at the Fisheries Exhibition, for example, that we have a cheap and economical light, and it is placed in competition with lights which give 3,000 candle-power, and which take, in proportion, a much greater horse-power to work them, and which therefore are a greater expense. Ours is an economical light, sufficient for all purposes, and has shown itself to the world as more efficient than any brought forward. I have seen it in Paris; it is the only light extensively used there. The French have had great opportunities of seeing the light, and they use it in the streets and in the magasins. In the Magasins Au Printemps they have it. The Parc de Monceau is also lighted by the electric light, and the authorities have made a contract with the French company, paying double what they did before. The report shows the number of works we have carried out. It would not be in the interests of the Company to enumerate those installations which we are asked at present to do. We have many inquiries, and we have more work offered than we can do if we had four or five times our present capital. With respect to subsidiary companies, soon after the formation of the company the time passed at which they could be formed; but at the present time arrangements are being carried out for the formation of a Scotch company. We have lighted up the Lyceum Theatre in Edinburgh, and also a theatre at Glasgow, and the Scotch people seem very anxious to carry this thing through. With respect to the financial position of the Company, unfortunately the balance-sheet shows that too clearly, but it might have been made to show better had some profits which we have really made been carried in. The profits shown here are £332 2s. 11d., but that, in our opinion, ought to have been about £900 more. We have done about £7,000 worth of work. The accounts have been placed in the hands of Mr. Mackay, the auditor, who has also been acting for us as accountant in making up our books, and who has thoroughly gone into every account, even to the smallest item. I do not think there is anything more to say, except to call attention to the last clause but one—namely, that we want more money to carry on the undertaking. We have manufactories, we have workmen to pay every week, in order to create a profit; and the only way we see to increase our finances is to propose that you should take up some of the debentures, which will be a first charge, and pay interest of 7 per cent. I may tell you (as you may know) that by the Articles of Association the Board of Directors consists of eight gentlemen. We have arranged that four of those gentlemen shall retire, and that four gentlemen elected from the body of the shareholders shall join those who remain. Then (and this will show our faith in the Company), we propose to alter Clause 66 of the Articles of Association. When we joined the Company we found that the directors had to have a qualification of twenty-five shares; we took them, but we propose to alter that, and to make it 200 instead. We also propose that in future the directors shall take no fees until the Company is in a prosperous condition. We feel we have done our best for the Company, and we have had a difficult task to perform. We have, however, made an established business; and I should regret very much if the shareholders do not think fit to provide funds to carry this undertaking on energetically, for I am quite sure it will be a highly-prosperous and successful undertaking. We also propose to reduce our establishment charges as much as possible, consistent with the actual progress of the Company. There is nothing in this life so successful as success; and if we had had the licenses confirmed by the Board of Trade for the Strand district, we should be in a very different position to what we are now. Circumstances and fate have been against us so far, but we stand before you with a well-established business at this moment, and the only difficulty at present is want of funds to carry it out [Hear, hear]. With these remarks I beg to move the adoption of the report and balance-sheet, and I shall be happy to answer any question which any shareholder may wish to put.

Colonel KEATE having seconded the motion,

Mr. LINDEL said he should move "That the report be not adopted." He saw that the amount set down in the balance-sheet for directors' fees was £2,806, salaries in the manager's department £1,754, rent and taxes £396, general expenses £714, and interest £121. These were large sums, but the item of "brokerage on shares" £4,640 he could not understand. He also saw £1,329 put down for legal and parliamentary expenses. These were very heavy expenses. He saw that they spoke of reorganising the Company in the sense of making the holding of each of the directors 200 shares; but he would like to know how many shares the directors at present held. He himself was the wretched holder of twenty shares, and if the directors held only twenty-five—which as far as he could see did represent their holding—then he regarded his position with respect to the directors as a considerable one. He should have thought they would have held at least 200. They had taken, too, £2,806, and that amount they had claimed because they had done work. What about the position of the shareholders, however? They were not going to get a halfpenny, and beyond that they were asked to provide more capital. He did not know how the directors could do so in face of such losses as the Company had had. The debts due by the Company were £16,572. They were a bankrupt company, and, if so, the best thing was to wind up and close the concern at once, and make the best of what was called in the balance-sheet patents and goodwill, £155,463 (which he hoped they would get), and £11,990, representing that which he did not suppose would fetch twopence. What was given by the Company, by the shareholders, for the concern? As the report said: "The lighting station at Charing-cross, a long wooden shed, with a 20 horse-power steam engine and dynamo, was the only workshop the vendors possessed. The other business of the vendors consisted in the supply of imported Jablachkoff candles, and repairs of fittings for the different customers in London and the provinces." It appeared to him that all they had got was this long wooden shed and the supply of imported Jablochkoff candles, and the few transactions mentioned at Whiteley's, &c. That was what they had bought, and for which they had paid these enormous sums. He contended that they had paid an enormous amount of money for that which was literally worth nothing, and now the directors called upon the shareholders to say that they were entitled to their salaries. He held that the shareholders were also entitled to remuneration. As to the proceeding of the directors in taking £2,806 out of the coffers of the Company, well all he could say was that he would not have done so, having regard to the circumstances of the Company. He repeated that the concern ought to be wound up, or that they should get some one to take it over from them, but not a farthing more would they have from him.

Mr. SIMON said he saw that the Company owed the bankers £9,368. What security did the bankers hold? They showed as assets £11,000 for manufacturing premises and lighting stations, plant, machinery, and fittings; stocks on hand, £8,742; debts, £2,337; deposits on water and gas meters, £15; and petty cash, £3. Altogether their assets amounted to £23,090, but if they wanted to sell those assets they would not obtain half that sum. Against this £23,090, too, they owed £16,572. He wished to know how they could repay those debts. The shareholders were asked for £20,000 more to carry on the business. How could they do that when they must repay this £16,500 to clear off their liabilities? The directors, he thought, had not acted as business men, having been simply guided by flourishing promises.

Mr. MANNERLEY asked if it were true that the directors had confiscated the shares of some of the shareholders on the ground that they had not paid the last call, and whether it were the fact that the shareholders whose shares had been confiscated had issued a writ against them for having obtained money by fraudulent misrepresentations? He believed, too, that the shareholders whose shares had been confiscated on the ground mentioned had also been excluded from that meeting.

Mr. CARTER (Huddersfield) stated that he held twenty-five shares, and therefore if what he had heard about the directors' holding were correct, he was as much interested in the Company as the directors. He had looked at the balance-sheet very carefully, and it was one to which he would not have liked to put his hand. The item of patents and goodwill was set down at £155,463. According to the prospectus which was issued originally they undertook to pay the vendor £150,000 for his patent, and he therefore wished to know what the Company had obtained for the extra £5,463. The chairman had said that about one third of the capital had been subscribed.

The CHAIRMAN: We have one third yet to issue.

Mr. CARTER: The prospectus stated that 10,000 out of 40,000 shares had been subscribed for. Had brokerage to be paid upon the 10,000 or not? The prospectus stated that the number of shares for public subscription was 40,000, but the balance-sheet now before the meeting stated that 18,961 had been subscribed. It seemed to him that the brokerage on the shares that had been subscribed was something very outrageous, and he would like to know who had had the money. It appeared to him from the balance-sheet, taking the figures as given by the directors, that they had an estate worth £23,000, out of which they owed £16,000. He could not see how the directors were to carry on the business of the Company with the £20,000 they asked for, and the calls in arrear, which were set down at £18,384. He would like to ask whether or not the building on the Embankment had been taken at cost price, as it seemed to him that it was worthless, except for bricks and mortar and old materials. He would support the amendment, and add the suggestion that a committee of shareholders ought to be elected at that meeting to make a thorough investigation of the accounts. It seemed to him that if properly dealt with a considerable amount might be recovered.

The CHAIRMAN observed that Mr. Carter had said that if the accountant had done his duty he would have found out some curious things. One thing he would have found out was that Mr. Carter had not paid his calls.

Mr. CARTER said he had been going to tell the meeting of that.

A SHAREHOLDER: I have not paid mine.

A SHAREHOLDER: Nor I.

The CHAIRMAN stated that the solicitor informed him that no gentleman who had not paid his calls had a right to vote or to move a resolution. The Company was placed in its present position in great measure through those shareholders who had not paid their calls. The great object which those who had not paid their calls might have in view was to depreciate the industry which those entrusted with the management of the Company had striven so hard to form.

Mr. CARTER (continuing) said he had looked carefully through the Articles of Association, and there was nothing to prevent him from speaking, though he could not vote. If the Company had been a satisfactory company his calls would have been paid freely. He would like to ask the secretary where he could put his finger on a single item of profit during the past year. The report said:—"A much larger business might have been done had the directors been content to take work at less than cost price, but this the directors were not, in the interests of the shareholders, prepared to do." Could he be informed where they had made any profit?

The CHAIRMAN: I may as well candidly tell you that I do not mean to answer any question put by those who have not paid their calls. Place such questions in the mouths of those who have acted honourably by the Company, and then the question will be answered. I place myself in the hands of those gentlemen who have supported the Company, and found the money for carrying it on.

Mr. LINDEL maintained that the chairman had no right to say that the directors had acted rightly, and that those who had not paid their calls had acted dishonourably. He (the speaker) was ready to pay his call immediately, and he would have done so before had he not been out of town. When he returned home he found an intimation that that meeting was going to be held, and he had thought that he need not pay until he had heard what the chairman had said.

Mr. STEINTHAL said he had always paid his calls immediately they had been made, with the exception of the last call, and the chairman was aware under what circumstances that had not been paid. He had not refused, nor did he refuse to pay it, but he had asked for the information upon which the call had been made. If, according to the chairman's ruling, not having paid the call, he had no right to be present at the meeting, he should at once leave.

The CHAIRMAN: I did not say that. I said that the opinion of our solicitor was that no resolution could be received from gentlemen who had not paid their calls, and that no question which such gentlemen put need be answered.

Mr. STEINTHAL expressed his satisfaction at the chairman's explanation. He had come there not to make any recriminatory observations. He did not wish to "cry over spilt milk," which he believed had been "spilt" honestly. He desired, moreover, to support the Board in any reasonable proposition they brought before the meeting.

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Mr. CASPER thought that the feeling of the meeting must to some considerable extent be with the gentlemen who had spoken, and that there were fair grounds for much that had been said, although there had been some misstatements. He, therefore, suggested that the chairman should deal with all the shareholders present in a kind spirit, not merely in accordance with the strict line of the law. With regard to the gentlemen who had already expressed themselves, shareholders generally invested their money without sufficient reflection, and the moment there was the least scare they said, with as little reflection as before—We will not make an effort to retrieve our position. For his own part, he maintained that the Company was in a perfectly sound and good position, and that it had the best future before it of any company for lighting with electricity. There was ample ground for the strongest regret that with the capital in hand the expenditure had been on too large a scale. On the other hand, they were to judge of the effects produced and not the causes. They were past, and it was for them to see that errors which had been committed were not repeated. It was for them to see whether there was a fair prospect for going on to a successful issue, and whether, when people spoke of winding up, it was not encouraging their enemies. Going to the balance-sheet, he found that a sum of £900 which had been earned had not been shown, and he thought it should have been. He found that business to the extent of £7,000 had been done last year, with £1,200 profit. The position of the Company was perfectly solvent. At the present time they had plant and material which every company pretending to do what this Company had to do was obliged to buy, and if this Company were wound up to-morrow, and another company wanted to carry on work similar to that done by the Company, that other company would have to purchase similar plant and material to that now possessed by this Company. The company similar to themselves in France had been in a worse plight than they, but this month they had earned enough to pay a dividend of 5 or 6 per cent. on a capital of £300,000. The Company had in plant some £20,000, and if they did not have it they would have to get it; they had debts owing to them to the amount of £2,300, and calls in arrears over £18,000. He made those good assets £41,000, against which they owed £16,000. Although, therefore, some people might think the Company bankrupt others did not. He believed if the shareholders did not subscribe the £20,000 asked for on debentures, the directors would get it elsewhere A large amount of the charges—a matter which he thought left much to be desired—were really establishment expenses. The purchase of their patents had not been made in a hole-and-corner manner, and whatever was given for them had been given with the shareholders' knowledge. They had enough to pay their patents and their debts, and there was a small capital in hand of £4,000 or £5,000. That was not an insolvent state. Again, a large amount of the total of £14,439 had been spent in establishing the Company; the directors would give up their fees until better times, and they were going to admit four gentlemen to the Board, who would see after the expenses. He agreed that it was better to wind up a company if, being in full work, it could not earn enough to pay its way. So far as regarded this Company, if they maintained their position they had before them a magnificent future. The expenses were going to be cut down, and he believed they would get into a position which would enable them to obtain a large amount of capital for the work that was before them. Besides giving up their fees the directors were going to admit other gentlemen to seats at the Board, and also to increase their holdings.

Mr. SIMON asked how a company could carry on business with about £3,000 in hand.

Mr. CASPER said that the working expenses of the Company should be at most £100 a week, and with £1,000 in hand there was enough to go on for ten weeks.

Mr. RICHARDS protested against the feeling going abroad that the shareholders were anxious for liquidation. He believed that with a patent like the Jablochkoff they could obtain any amount of money they required, even though the shareholders refused to risk it themselves. Having gone through the troubled waters of the past year, there seemed a good opening for them in future. He was, however, entirely opposed to any more money being thrown away in expenses in opposing the powers obtained by the Edison Company for the Strand district, for the Edison and the Swan Companies had now amalgamated.

Mr. PARSONS desired information as to the brokerage upon the shares, and he inquired if the directors had power to issue debenture capital.

Mr. TAYLOR said it behoved the shareholders to put their shoulders to the wheel to prevent the Company going to the wall. He had looked closely into the affairs of the Company, and he believed they were perfectly solvent. Their expenses, however, must be kept down. All that was now wanted was sufficient to keep the business going, and it was a business which he said had prospered immensely in France. He was honestly convinced that this Company possessed the only system that was worth anything. An advantage with this system, which perhaps was not sufficiently understood, was that with their arc light they could run the incandescent light.

Mr. LOENFELDT observed that it was now about five years ago that Jablochkoff invented this light, and since then some thousands of scientific men had been trying to improve on it, and had, he maintained, failed. What they had to do was to devise means to keep the Company a going concern for the next two or three years. There were a good many gentlemen in the City who desired to see the Company wound up, but he reminded the shareholders that in the event of liquidation the calls would have to be paid.

Capt. EVANS expressed his belief that the Company was quite solvent. He strongly urged union among the shareholders.

Mr. MEYERS, of Messrs. Samuel Bros., Ludgate Hill, testified from personal experience to the merits of the Jablochkoff light, his firm having used it for upwards of four years, during which time he never had occasion to call in an electrician.

Mr. MATHEWS maintained, in spite of what some of the previous speakers had said, that the Company must possess an asset in its patent, for which they had given £150,000.

The CHAIRMAN said that a great many of the questions asked had been answered by subsequent speakers. ["Vote, vote."] He wished to ask Mr. Lindel whether he desired to press his motion.

Mr. LINDEL withdrew it.

The CHAIRMAN then said that as it was the wish of the meeting that the motion for the adoption of the report should be put he would do so. Having submitted the motion in the usual way, he declared it carried unanimously amid applause.

Mr. R. Mackay having been re-elected auditor for the ensuing year, a vote of thanks was passed to the chairman.

The CHAIRMAN, in reply, expressed his confidence in the Jablochkoff system, and observed that nothing but the practical success of Mr. Jablochkoff had brought other imitators in. He was certain that the Company could not have a more established and promising business.

The meeting afterwards proceeded to the appointment of a committee to consider the selection of gentlemen to seats at the Board, as suggested by the chairman.

YORKSHIRE BRUSH ELECTRIC LIGHT AND POWER COMPANY (LIMITED).

The annual general meeting of the shareholders of this Company was held on the 11th instant, at the City Terminus Hotel, under the presidency of Mr. Henry W. Lowe.

The SECRETARY (Mr. George L. Morton) having read the notice convening the meeting,

The CHAIRMAN said: I beg now to move the adoption of the directors' report and statement of accounts as presented, and in so doing I feel that I shall not be called upon under present circumstances to make any lengthened remarks. The report shows you exactly our position and prospects, and if it were not for the possibility of bringing to a successful result the negotiations for amalgamation I should deem it essentially necessary to go more fully into the position of the Company. Electric light companies have had to face very enormous difficulties, and these have formed the subject of so much discussion lately, that I cannot put them before you as any new feature. I must, however, confess that my belief in the future of the electric light has not abated one single iota; but at the same time I think unless facilities are given for its expansion, we cannot look for any material improvement for some time, though if the light were to become more generally known, and experience extended with this knowledge, it is very likely that those facilities may be forced from the authorities at no very distant date. However, the interval is very uncertain. As an illustration of what electric lighting might have been by this time but for the restrictions which have been thrown in its way, I may point to our works at Middlesbrough. There we have the lights fully and satisfactorily at work. They are giving every satisfaction to the consumer; they are perfect in every detail, and they are financially successful, because we can work them at a profit. I am sure that if we had had the same scope for this work that gas has been accorded, or any other large industry, we should have been able to show very different results in our balance-sheet than we have been able to present to you. We have had a year of difficulty and constant expense, being retarded at almost every step we took, and fettered in nearly every direction; but in that direction where we have not been fettered we have had a most undoubted success, and I think it is a prominent example of what may be done in this country when the companies are allowed free use of the materials at their disposal. As regards the question of amalgamation, no doubt it is a very essential one for us to consider, and I am glad to say that after some long and tedious negotiations we see our way clear to bring this about; and I hope, in a few days at most, to be able to lay before you a scheme which I feel certain will be received by you as satisfactory, and it will give a market for cash value of the shares we now hold. He concluded by moving the resolution.

Major-General J. BATES seconded the motion.

The CHAIRMAN, in reply to Mr. Griffith Jarrett, said that they had thirty-one lamps at work at Middlesbrough, working from a 40-light machine, and they were producing a rental of £25 each per lamp. He could not state the cost per lamp to the Company, for the cost was not worked out in that manner, but he could state the cost for the full 40 lights. He might, however, state that the consumers were pressing the Company for a reduction in the price per lamp. They had offered as an inducement to the larger use of the light that as soon as they took off another 40 lights they would reduce the cost by £5 per lamp. He did not mean to say that the Company could afford to carry on working at Middlesbrough and Leeds, and have an office in London and pay all the attendant expenses out of the profit on the works at Middlesbrough. By themselves, however, they were in a very good position. He had always considered that they would be very saleable, and that in two or three years they would form a very good sub-company.

Mr. STOBART could not see the necessity of the Company having a London office at all, for it appeared that Yorkshire was the only place they worked at.

The CHAIRMAN said that if they had intended to carry on the Company separately the last remark would have been one for very serious consideration. The staff had been reduced to a minimum, but it would be understood that in a company seeking business a staff must be kept ready to take up work when it was offered. They had been saddled with this expense. The amalgamation scheme, however, was so very near coming to a point that the question was scarcely worth considering. A meeting of the shareholders would be called to consider the scheme, and if it were not approved, then the proposal for changing the residence of the Board might be gone into fully, and the directors would support such a proposal. They hoped in a day or two to get the scheme in writing, and to place it before another meeting in about ten days. In reply to Mr. M'Alister, he added that he would undertake on the part of the Board that the shareholders should have an opportunity of discussing fully the affairs of the Company at the next meeting, which they would call not merely to consider the amalgamation scheme, but also the present position and prospects of the Company.

Mr. FELL contended that if the present meeting passed the report and accounts they could not be discussed at the next meeting.

Mr. M'ALISTER observed that if that were so he would move as an amendment that the adoption of the report and accounts be deferred.

Mr. JARRETT seconded the amendment.

The CHAIRMAN stated that the balance-sheet as it stood could not be altered. All that could be done, indeed, was to pass strictures on those who had charge of the Company's affairs. The directors had striven to do

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their duty, but the result, he admitted, had not been satisfactory. They must, however, in their public capacity, not object to being criticised, and they must give as satisfactory explanations as they could.

Mr. M'ALISTER said he did not wish to pass any strictures on the Board, but at the last special meeting assurances were given that the Company was doing fairly well, and that a satisfactory result would be shown as to the year's working. On those assurances the vote of the meeting was passed, and he had no doubt that it was mainly secured as against any proposal to wind up the Company which was before the meeting at that time. Within a short time of that meeting, however, he found that instead of saving their capital they had lost 6 per cent. of it. He was not saying that theirs was a more unsatisfactory balance-sheet than that of other electric lighting companies—on the whole, indeed, he thought it was more satisfactory than some of them, and perhaps on the whole it was more satisfactory than the shareholders had a right to expect; but what he wished to draw attention to was the fact that the chairman and the directors had held out hopes that they would do better. He would have been content at the last meeting if he could have got back his capital, foregoing any interest, but, as he had said, they had lost 6 per cent. of their capital. Personally, he had not a word to say against the directors, and he believed that every statement made by them had been in good faith.

Mr. JENKINS held that a thorough explanation of the affairs of the Company ought to be given. On the 27th of August a large number of their shares were disposed of at a monthly sale in the City at 5s. per share, with £2 paid, while in the case of another company—which, in his opinion, was certainly in no better position than theirs—shares worth £2 had been sold for 10s Had the litigation, or the financial position of the Company, or any other special cause led to this difference in value? He would have liked to see a more detailed statement, showing the profits or otherwise which had arisen from the working at Middlesbrough, as it would have afforded some index, on a limited scale, as to what the future of the Company would be when it extended its operations to the greater part of Yorkshire.

Lieut.-Colonel H. C. BYRDE (a director) said that from personal inspection of the works at Middlesbrough he could not conceive a more favourable situation for what they had to do. The North Eastern Steel Works, where their lighting was first taken, were now running several lights. These works were also being considerably extended, and would require at least 100 more lights and a great deal of incandescent lighting. There were wharfingers' and other works all in the same circuit who would all very soon make use of the electric light, but to increase the capabilities of the Company to furnish that lighting it would be necessary to put up more steam engines, more dynamo machines, a great number more lights, and to increase the staff. These works happened to be outside the corporation of Middlesbrough, and were not hampered by any Governmental restrictions, and, consequently, had free scope for their operations. The works at Middlesbrough, indeed, formed the nucleus of a very satisfactory company. A company desiring to supply the whole of Yorkshire with the electric light would require a capital—not of £20,000, but of £1,000,000. When this Company was formed it was expected that they would make considerable profit on the sale of plant, &c., but these hopes had been frustrated by the impediments which had been thrown in the way of the adoption of the electric light. The Leeds Corporation invited tenders for lighting their buildings. The staff of this Company was employed for a month or two preparing plans and estimates, but after all the trouble taken in that way, the corporation required an amendment of the specifications. This was done, and they were submitted again. Other companies also sent in tenders. After some two or three months' more discussion, the Leeds Corporation decided to give up electric lighting altogether for the present, and thus the whole of the expenditure which had been incurred by the Company was thrown away. That gave the shareholders one instance of the difficulties against which the directors had had to contend. The only better prospect for them was an amalgamation with a stronger company.

The CHAIRMAN said the question had been asked, In what way had the Company been prejudiced by the litigation at the commencement of its career? He could only say, in reply, that from the time the petition for winding up the Company was lodged it gave them such a bad name that no one would look at any offer they made. They said, "You are going to wind up." The directors said "No;" but the litigation went on for two months at least, and during the whole of that period the Company was "between wind and water." They could not undertake contracts, but could only seek them, and go on as far as they could in that way. They had the very best chance in the world of getting the order referred to from the Leeds Corporation. Theirs was a local company, and preference was given to them by the great majority of the municipal council; but what was feared by the corporation was that there might be another quarrel between the directors and the shareholders in the midst of the arrangements. This feeling, no doubt, had operated with the corporation in selecting Crompton and Co. for the small order obtained by that firm, but which he (the speaker) thought was the "thin edge of the wedge" for the larger work when the corporation went into the matter. In the item in the balance-sheet of "Claims Against the Hammond Company, £5,944," they had debited the legal costs which had arisen in connection with those claims, feeling that it was through that company that those costs had been incurred. As to the difference between the hopes expressed last January and the actual results, as now shown, they had excellent prospects in January at Middlesbrough, as they had now, but they had been working through the summer, and in the eight months there had been no actual results beyond the addition of a few lights. The winter, however, was now coming on. He did not think it would be wise, in the interest of the Company, to answer the question as to the definite profits on the work they had done. The information could, however, be given privately to the shareholders. The staff had caused heavy expense, and the return had not been of corresponding amount. They had also been prejudiced as to their expenses by having to reduce the price of the plant and material which they had sold. They had bought a good amount of stock on the assurance from the Brush Company that the report which was in circulation at the time, that the Company was going to make a large reduction in the price of its machines, &c., was untrue. Within about a month from that time, however, the Brush Company reduced the price by about 25 per cent., and this Company had to follow suit. As to the sale of this Company's shares, he believed that a member of the Stock Exchange had failed, and that his shares were sold at public auction, but he (the chairman) did not know what price they fetched, and the transfer had not been lodged yet. The item of £65,000 on the credit side of the balance-sheet represented simply the price of the concession. Roughly he should say that altogether they had made a profit of from £700 to £900.

The amendment was then withdrawn, and subsequently the original motion was carried unanimously.

On the motion of Lieut.-Colonel BYRDE, seconded by Mr. JARRETT, and warmly supported by Mr. M'ALISTER, Mr. Lowe was re-elected to his seat at the Board; and the auditors (Messrs. Tribe, Clarke, and Co.) were afterwards reappointed.

A vote of thanks to the chairman terminated the proceedings.

COMPANIES' SHARE LIST.

TELEGRAPHS.

COMPANIES.	CLOSING PRICES Oct. 10.		BUSINESS DONE WEEK ENDING OCT. 10. Highest.	Lowest.
Anglo American	45¾,	46¼	46	44¾
Do. Preferred	76¾,	77¾	73	75¾
Do. Deferred	15¾,	16¼	16	15¾
Brazil Submarine	10¼,	10¾	10¼	10¼
Cuba	10½,	11	10¾	10½
Do. Preference	17,	18	—	—
Direct Spanish	5¼,	5¾	5¼	—
Do. Preference	15¾,	16¼	—	—
Direct United States Cable	11¾,	12¼	12¼	11¾
Eastern Telegraph	10 15-16,	11 1-16	11 1-16	10⅞
Do. 6 per Cent. Preference	12⅞,	13⅛	12 15-16	—
Do. 5 per Cent. Debentures, 1899	103,	107	102¼	—
Eastern Extension	11⅝,	11⅞	11 11-16	11½
German Union	10,	10½	—	—
Globe Telegraph and Trust Company	7½,	7⅝	7⅝	7⅜
Do. Preference	12¾,	13	13	12 13-16
Great Northern	12¾,	13¼	13	—
Indo-European	31½,	32½	32	31½
Mediterranean Extension	1½,	2	—	—
Do. Preference	2,	4	—	—
Reuter's	8¾,	9¼	9	—
Submarine	215,	225	—	—
West India and Panama	¾,	1	¾	¾
Do. 1st Preference	6½,	6¾	—	—
Western Brazilian	5¾,	5⅝	5⅝	5 7-16
West. Union 7 per Cent. 1st Mortgage	122,	124	—	—
Do. 6 per Cent. Sterling Bonds	100,	103	—	—

TELEPHONES.

Consol. Telephone and Maintenance	5-16,	7-16	—	—
Oriental	5-16,	7-16	5-16	—
United Telephone	8¼,	8¾	8⅝	8 7-16

ELECTRIC LIGHT.

Anglo-American Brush Lgt. (£7 paid).	2¼,	2½	2¼	2¼
Do. (fully paid)	4,	5	4½	4 5-16
Hammond Light (£3 15s. paid)	2,	2¼	2⅛	2 1-16
Eastern Electric (£4 paid)	1⅝,	1⅞	—	—
Swan	1¾,	2	2¼	1 13-16
Maxim-Weston	3-16,	5-16	¼	—

MISCELLANEOUS.

Telegraph Construction	33¾,	34¼	34	33⅞
India Rubber, Gutta Percha, and Telegraph Works	—,	—	31	30¾

TRAFFIC RECEIPTS FOR SEPTEMBER, 1883.

COMPANIES.	Sept., 1883.	Sept., 1882.	Incrse.	Decrs.
Anglo-American Telegraph Company	—	—	—	—
Brazilian Submarine Company	—	—	—	—
Cuba Submarine Company	2,500	2,283	217	—
Direct Spanish Telegraph Company	1,701	1,812	—	111
Direct United States Cable Company	—	—	—	—
Eastern Telegraph Company	42,778	57,271	—	14,493
Eastern Extension Telegraph Company	37,271	32,955	4,316	—
Great Northern Telegraph Company	23,640	—	—	—
Submarine Telegraph Company	—	—	—	—
West Coast of America Telegraph Company	—	—	—	—
Western and Brazilian Telegraph Company	—	—	—	—

NUMBERS OF "THE ELECTRICIAN" OUT OF PRINT.—The following numbers of *The Electrician* are out of print, and cannot be supplied at the office, viz.:—Vol. 1, Nos. 3, 9, 19; Vol. 7, Nos. 8, 10, 12 to 18, 20, 21, 24 to 26; Vol. 8, 1, 3, 6 to 12, 15 to 26; Vol. 9, Nos. 2, 4, 24, 25; Vol. 10, No. 13.

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NOTES.

THE BOARD OF TRADE.—Mr. T. H. Farrer, Permanent Secretary to the Board of Trade, has had a baronetcy conferred upon him.

THE TELEPHONE AT BROUGHTY FERRY.—The National Telephone Company have opened an exchange at Broughty Ferry, near Dundee.

KIDDERMINSTER.—A movement is on foot to erect science schools in this town. Already a large sum has been subscribed towards the building fund.

BERLIN UNIVERSITY.—On Monday last Professor Kirchhoff assumed the chair of Rector Magnificus of Berlin University, as successor to Professor Dubois Reymond.

THE NEW MUNICIPAL BUILDINGS AT GLASGOW.—The telephone is to be used to communicate between the different rooms of the New Municipal Buildings at Glasgow, the foundation stone of which was laid last Saturday.

WESTERN UNION TELEGRAPH COMPANY.—The annual report of this company shows gross receipts 19,945,902 dollars, and expenses 11,794,553 dollars, the net earnings being 7,660,349 dollars, an increase of 542,279 dollars over the previous year.

BOOK RECEIVED.—"The Patents, Designs, and Trade Marks Act, 1883," with introduction, notes, and index to the sections relating to patents, by James Johnson and J. Henry Johnson. Published by Longmans, Paternoster-row, and Stevens, Chancery-lane.

MAICHE'S ELECTROPHONES.—Experiments were made with the electrophones of M. Maiche, on the 6th inst., on a telegraph wire between Paris and Mantes, a distance of about 65 kilometres. They are stated to have been successful, conversation being clearly heard.

WEST INDIA AND PANAMA TELEGRAPH COMPANY.—The estimated traffic receipts of this company for the half month ended the 15th October are £2,278, as compared with £1,589 in the corresponding period of 1882. The June receipts, estimated at £5,018, realised £5,060.

ATMOSPHERIC ELECTRICITY.—*L'Electricité* says that during a recent thunderstorm a curious sight was witnessed between two stations on the Dombes line of railway. The supports of the wires on the telegraph poles were ornamented with small tongues of fire, whilst from time to time flashes of fire were seen to leap towards the clouds.

WEST COAST OF AMERICA TELEGRAPH COMPANY.—This company have received the following telegram from South America *viâ* Galveston, relating to the messages forwarded and received by the new route, which was opened on the 21st September:—"Lima reports to-day vast improvement, good dates from everywhere in South America, including the Brazils."

ELECTRIC LIGHT IN MINES.—In the Reports of Her Majesty's Inspectors of Mines we notice that Mr. Foster states that the first mine in any district which had recourse to electricity for illuminating purposes was Foxdale, in the Isle of Man, where Maxim incandescent lamps are still employed at the bottom of a large shaft for giving light to the men engaged in sinking.

THE TELEPHONE IN DUNDEE.—On Tuesday last the National Telephone Company's branch at Dundee established communication through an eight-wire cable, laid across th Tay, which is put down for the purpose of connecting Tayport and Newport with the company's Central Exchange in Dundee. The length of the cable is about 1¾ mile. Speech is reported to be very clearly heard through the cable.

INCANDESCENT LIGHTING IN WHITEHAVEN.—The shops belonging to Messrs. Whittle and Son, of Roper-street, Whitehaven, have been lighted by 100 incandescent lamps. The current is supplied by a Ferranti dynamo, driven by a 12 horse-power steam engine. The work has been carried out by Mr. Watson Bell, of Whitehaven. Most of the fittings have been supplied by Messrs. Winfield, of Birmingham.

THE ROYAL SOCIETY OF VICTORIA.—The nineteenth volume of the *Transactions* of this society, just received, shows that electrical matters form a subject of considerable interest in the colony. Mr. R. E. Joseph read before the society a paper on electric lighting, and Mr. P. Behrendt one on electric railways, the former paper appearing in this volume, the latter being simply mentioned, and will probably appear in the next volume.

THE FERRANTI DYNAMO.—A thousand light machine, constructed upon the Ferranti system, was shown in action at the works of the company, Appold-street, Finsbury, on Wednesday evening last. The trial was with 840 Swan 20 candle-power 100 volt lamps (nominal), and seemed in every way satisfactory. A number of diagrams were taken from the engine—one by Fowler, of Leeds—and the figures obtained from these, as well as the purely electrical data, together with illustrations of the machine, will be given next week.

THE GENERAL POST OFFICE.—The additional story to the new Post Office building (the telegraph department), which is being constructed at a cost of over thirty thousand pounds, is rapidly progressing, about half of the work having been done. No interference with the traffic in St. Martin's-le-Grand is caused by the work, an immense staging having been erected on the main building itself, thus obviating the necessity of scaffolding, except at the rear of the building in Bath-street, where materials are drawn up and the workmen ascend.

THE FORTHCOMING CABLES CONFERENCE.—Mr. C. M. Kennedy, C.B., of the Foreign Office, Mr. C. Cecil Trevor, C.B., Assistant Secretary to the Board of Trade, and Mr. C. H. B. Patey, Third Secretary to the Post Office, are proceeding to Paris as British delegates to the Submarine Cables Conference. Lieut.-Colonel Bateman Champain, R.E., will be delegate for British India, and Sir Charles Tupper, K.C.M.G., delegate for the Dominion of Canada, at that Conference. Mr. A. Law, of the Foreign Office, will act as secretary to the British delegates. The first meeting of the Congress took place on the 16th inst.

OVERHEAD WIRES IN LONDON.—A letter has been received by Mr. Preston, clerk to the vestry of St. Luke, E.C., from Mr. Hamilton, 10, Downing-street, S.W., acknowledging the receipt by Mr. Gladstone of a resolution recently passed by the vestry, as to overhead wires, and stating that "the Prime Minister understands the Post Office authorities are endeavouring to diminish the number of such wires belonging to them, but that it is only in respect of these wires the Government is able to take action." We notice that the Islington Vestry are taking the overhead wire question up.

THE PATENTS ACT.—At a meeting of a Committee of Engineers and Inventors (appointed by the Balloon Society), on Saturday last, Mr. W. H. Le Fevre, C.E., in the chair, the following resolution was carried unanimously:—"Owing to the ambiguity of the wording of the Patents Act, 1883, with reference to all patents applied for between September 1,

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1883, and January 1, 1884, it is for the interest of inventors and the public that no further patents be taken out until January 1, 1884, when the new Act comes into force." This may be a wise resolution, but its movers will hardly get inventors to act up to it.

Electric Motors and Balloons.—M. Tissandier, of Paris, a well known and enthusiastic balloonist, made a trip from near Versailles to Chatou in a specially constructed balloon, furnished with a screw governor driven by an electric motor. The current was supplied by bichromate cells. The motor was one made by the firm of Siemens, and was connected with the screw, consisting of two lutestring wings or sails of about 2·80m. diameter, by means of gearing. It is stated that during his trip, which lasted for about three hours, M. Tissandier made several successful trials of his screw governor, although a strong wind was blowing.

Electric Lighting for Ships.—The Swan United Electric Light Company have received the order to fit up the White Star line steamship "Adriatic" with Swan lamps. Siemens's alternate current dynamos will be used, and they will be duplicated to provide for contingencies. The dynamos will be driven by two pairs of powerful coupled engines, by means of rope belting. The total number of lamps employed will be 132, of 20 candle-power, and 150 of 12 candle-power. Should this installation prove satisfactory to the owners of the vessel, it is their intention to introduce incandescent lighting into others of their large fleet of steamers.

The German Union Telegraph Company.—We understand that negotiations which have been going on for some time past between this company and the British Government, for the establishment of a relay station at Lowestoft, through which place the company's Emden cable passes, have been successfully brought to a termination. The company are erecting a building at Lowestoft suitable for their requirements, and it is expected that it will shortly be ready. This will greatly facilitate the despatch of business over the company's cable, the present system of working without a relay having been found to be inadequate for the increase, as well as the rapid despatch which the traffic requires.

An Observatory on Ben Nevis.—A substantial observatory has at last, through the exertions of Mr. Clement Wragge and the generosity of Mrs. Cameron Campbell, been established on the summit of Ben Nevis, 4,406ft. above the sea level. By this means continuous observations will be able to be made all the year round and at all hours, instead of only during the summer months, as in former days. The observatory is connected by wire with Fort William Post-office, seven miles away. For the first part of the distance poles are used, but higher up the mountain the wire is laid underground, safe out of the way of wind and snow. It is intended to open a public telegraph office on the top of the mountain.

Truth Stranger than Fiction.—A good joke is often spoilt by dwelling too long upon preliminaries, and we shall therefore avoid discursiveness. In these days of school boards and science departments, of examinations and certificates, it is hard to realise the following: The Electrical Power and Storage Company had occasion recently to lend a secondary battery charged and ready for use. For the carriage the railway authorities claimed 22s. 6d. The battery was used and returned, the railway authorities now claiming 17s. 6d. A remonstrance was made as to the excess of charge in one direction over that in the other, which was met by the reply: Oh! but the cells were fully charged going, and returned empty, hence the difference in the carriage.

Electric Lighting of Railway Carriages.—A new voltaic battery has been on exhibition at the offices of Mr. Wm. Gammon, manager of the South Wales Department of the London and South Western Railway, 31, Nicholas-lane, W.C., during the past week. It has been brought forward as a source of current for incandescent lamps in railway carriages. The inventor claims that his battery will work for twenty hours at a time, and that the weight required to be carried to feed lamps equal to 160 c.-p. is but 3½cwt. He also claims that the waste products of the battery can be profitably sold, and expenses cut down in this way. We offer this information with all reserve, as we have not at present had an opportunity of testing the inventor's figures.

New Form of Arc Lamp.—A large number of new lamps, called the double disc lamp, are now being manufactured at Messrs. Crompton and Co.'s Arc Works, at Chelmsford. The peculiarity of the lamp is its simple mechanical construction, complicated clockwork being dispensed with, and the whole being controlled by one solenoid, wound differentially so that the lamps can be worked in series to any number in the same circuit. This improvement is due to Mr. T. C. Crabb, and was patented in May last. The lamp has been successfully tested on the exterior of the Arc Works. It has two sets of carbons, so that when one carbon is consumed the other automatically becomes lighted, without the slightest break in the illumination. The two carbons will burn 17 or 18 hours without being replaced.

The Telephone in Bristol.—The Bristol Exchange of the United Telephone Company was established in 1879. Its progress may be gathered from the following figures:—On the 27th February, 1880, there were 20 subscribers, and the number of calls amounted to 340 per day. On the 26th February, 1881, the number of subscribers was 88, and the number of calls 1,915; on the 25th February, 1882, the subscribers numbered 154, and the calls per day 3,261. On the 24th of the same month in this year the numbers were:—Subscribers 235, calls per day 6,669; whilst on the 22nd of last month (September) the subscribers had increased to 266, and the calls per day to 8,401. The exchange is open day and night, excepting Sunday. The annual subscription is £15 to all within one mile of the exchange, £2 2s. extra being charged to those who require the telephone by night as well as day. We may add that the United Company's manager for Bristol and the west of England is Mr. H. F. Lewis.

The Strike of Telegraphers in America.—Speaking of the lessons of the recent strike in America, the *Operator* says:—"'No one wanted a strike,' but, since a strange combination of circumstances forced such a deplorable state of affairs, it is a pleasure now to look back and reflect how almost each individual bore himself so bravely through all those long, weary weeks. But more satisfactory still is the genuine spirit of conciliation shown by the officials towards their returning *employés*, and the evident desire to remove any well-founded cause for complaint. This spirit, if encouraged, will soon lead to the conviction that operators do not need to 'strike' for privileges which, under a proper and temporising method, they might easily earn as a reward, and and will, furthermore, leave a doubt in the minds of many whether or not positive success in the late strike would have been as beneficial to the men as the so-called failure has already been. A pronounced success might have shown us here and there subordinates becoming too consequential and over-bearing. The more enthusiastic of the advocates of strong measures have ridden their theories to death, and, as

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our correspondent remarks, 'the war is over.' It was courteously conducted on both sides—a veritable 'civil' war—the men have, as a rule, been generously treated, and they should not forget to make a fitting return."

French Telegraphs.—The *Standard* correspondent, telegraphing on Friday last, the 12th inst., says:—"The Budget Committee met to-day to hear M. Charles Ferry's report on the Budget of Posts and Telegraphs. That report, which proposes a reduction of 1,600,000fr., was adopted. The opinion of the committee was very divided whether or not the works undertaken for the establishment of subterranean telegraph lines should be continued. Contrary to M. Cochery's opinion, several members maintained that with that kind of telegraph line the isolation [insulation] is far from being complete, and that before proceeding further with the works it would be advisable to wait till science had found a means of reducing the force of the currents of induction. They added that the expensive nature of these lines is another objection to their adoption. In the preamble of his report M. Charles Ferry points out that the expenses of the various services have increased in the proportion of 50 per cent., whereas the receipts have only increased 25 per cent. He gave expression to the fear lest the Budget of the Posts and Telegraphs should become an expense instead of a source of revenue."

Magnetic Rails.—Our contemporary, *L'Electricien*, has the following:—"We take the following from a trade contemporary:—'A professor of the Faculty of Sciences of Marseilles, together with two permanent way engineers of the Paris-Lyons-Mediterannée Line have just made some curious experiments on the rails laid between Marseilles and Rognac. They have ascertained that all the rails that have been laid some time have been transformed as to their two extremities into powerful magnets, capable of attracting and holding iron kegs and even stronger articles. If the rails be raised they keep their magnetism for some time, but gradually lose it. Two poles are formed at the corresponding ends of two rails of opposite sign. The production of magnetism in the rails in use is to be explained by the friction resulting from the running of cars on the track. It is certain that the magnetism thus developed exerts a useful influence on the stability of the track and increases the hold of the wheels on the rails.' Without contesting the fact itself, which does not appear very surprising to us, we should be glad to know how far this magnetism can increase the hold of the wheels, which in a locomotive often carry 4 to 6 tons each, above all when the rails are placed end to end, and mutually destroy one another's magnetism."

Overhead Wires in Wandsworth.—For some time past there has been a difference between the General Post Office and the Wandsworth District Board of Works on the subject of overhead wires. The Board object to them as being dangerous to life, and require the Post Office to put them underground. The Post Office object, and have taken out no less than seventeen summonses against the Wandsworth Board of Works. These summonses were heard before Mr. Paget, at the Wandsworth Police Court, on Wednesday. After the Board's defence had been heard, Mr. Casserley explained the position of the Post Office. It was the great desire (he said) of the Postmaster-General to have as few wires overhead as possible. In October last an application was made to place a wire to connect the Upper Tooting Fire Station with the Metropolitan Police Station in Lower Tooting, it forming part of a circuit. The expense of putting up six wires in the Tooting circuit overhead was £177, and the rental from the Metropolitan Board £49. The expense of the same system by underground wires was £1,750, and the rental paid by the Metropolitan Board £250. Therefore it was a serious item of public money, and were they to pay ten times as much for the accommodation which could be obtained in another way?—Mr. Lane, on behalf of the Wandsworth Board of Works, in reply to the magistrate, said he should call witnesses who would speak to numerous instances of poles and wires having given way partly from the effects of gales and other causes. The further hearing of the case was adjourned.

Intercepting Telegrams.—On Friday, October 12, four men, named J. Edwin Garside and Septimus Lockinwood Lamb, telegraph clerks, William Britain, newspaper publisher, and Henry Hulme, compositor, employed at the *Manchester Evening Mail* office, were charged at the Manchester City Police-court, under the Post Office Telegraph Acts, the former with having on September 24th and other days made known the contents of certain telegraphic messages, and Britain and Hulme with having endeavoured and procured Garside and Lamb to make known the contents of such messages. The defendants were also charged with having conspired and combined together to intercept the contents of the telegrams. According to the opening statement of the counsel for the prosecution, there was a private wire between the chief telegraph office in York-street, and the office of the *Evening Mail*, over which information of a sporting character, as well as other items, was transmitted. So far back as the middle of July last, the two prisoners employed at the *Evening Mail* office entered into an arrangement with the other prisoners, by which they were able to obtain from them the results of races some four or five minutes in advance of the official message being sent through the private wire. The object of this was seen in the fact that Britain and Hulme had been in the constant habit of sending money to the local betting clubs directly they received information as to the winning horses, and placing it on them. This had been done on some occasions as often as three or four times a day, as he should be able to show by the evidence of the boys who conveyed the intelligence for them. Witnesses would be called who would speak to having seen Garside actually engaged in the operation of tapping the wire at the chief office, and the information he thus obtained would be traced to the *Mail* office, although a sort of secret code had been agreed upon between the prisoners.—Some formal evidence was then given, and, upon the application of the defending solicitors, the case was adjourned.

Electric Lighting in the City.—The following extracts from the report of the Select Committee on Electric Lighting in the City to the Commissioners of Sewers, mentioned in our last issue, give further particulars, which will no doubt be interesting to our readers. The report says:—"The Edison Company propose to enter into contract for the area now lighted by them, viz.:—The Holborn-viaduct as shown by plan, and to supply also the General Post Office, and they would supply the public lamps within the area 'on the same terms as those now in force with the gas company.' And to private consumers they propose to charge at the minimum rate of 9d. a unit. The proposal of the company is virtually to render permanent the installation established by them on the Holborn-viaduct, and to supply in addition the General Post Office; these would form their compulsory area. Newgate-street is also shown on the plan as a proposed optional area, but it appears that the company are not in a position to extend their operations beyond the compulsory area from their present plant and station. The Gülcher Company propose to light

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compulsorily within the time required by the Board of Trade the area including Bishopsgate-street (from Threadneedle-street to Houndsditch), Houndsditch, and Aldgate High-street. They propose as a permissive area the district bounded on the west by King William-street and Gracechurch-street, on the south by the River Thames, extending to the City boundary on the east, and joining the aforesaid compulsory area on the north, but inasmuch as this permissive area has been deemed too large, the company have intimated their willingness to meet any reasonable proposals in the matter which the Commission may make. For street lighting the maximum charge would be £1 5s. per quarter for the current necessary for each 20 candle-power nominal Crookes incandescent lamp, £2 7s. 6d. per quarter for the current necessary for each 40 candle-power nominal Crookes incandescent lamp, and £12 per quarter for the current necessary for each Gülcher arc lamp of 2,000 candle-power nominal, and in proportion for larger or smaller lamps. For private lighting the price would be 8½d. per commercial unit. For carrying the wires into private houses the company would charge for each Crookes lamp 5s., and in addition the consumer would have to pay for fixing at a rate per foot of wire, depending on the number of lamps, and the cost of excavation, breaking walls, ceilings, &c., and making good. As regards the public lighting, it is estimated that the proposal of the company provides at least 30 per cent. more light than is now received from gas, at the same cost."

Rather Mixed.—Readers of the *Daily Telegraph's* leading article of the 15th instant must have risen from its perusal with very mixed ideas of the past, present, and future of electricity. The writer begins cautiously. "Shall we ever ride in cabs and omnibuses lighted by electricity?" he asks, and replies to his own question thus, "It is not impossible." So far so good, but a little lower down we read, "Several of our theatres have made us already familiar with actresses who carry dazzling stars in their hair, and at the tips of their artificial wings, for which they are indebted to 'dynamos' invented by Edison, Hopkinson, Jablochkoff, Werdermann, or to some other artist in electricity." Our writer has evidently begun to get out of his depth here. We never knew before that the Jablochkoff or Werdermann dynamo had much to do with the fairy lights employed at some theatres. Indeed we strongly suspect that the public reading the above quoted sentence will imagine that the lamps carried by the fairies are fed direct from dynamos. The *Daily Telegraph's* artist in writing would have been more likely to convey a correct impression if he had written secondary batteries instead of dynamos, and omitted the names that follow. As secondary batteries are charged by dynamos, we suppose indirectly actresses are indebted to them for the current which keeps their lamps alight, but what a small acquaintance with his subject the writer of the article displays in his mention of the dynamo inventors. Here is another typical sentence:—"But what does the luminous ray of a 'lightning bug' amount to when compared with the intense flash projected from an electric battery?" a "lightning bug" being the American for a firefly. Further on the writer says that electricity is not a new discovery. All that is new about it is "the transmission of a patent and long-discovered energy." He then consults his encyclopædia, and sails fairly through nearly a quarter of a column, from Thales of Miletus to Michael Faraday. A few quotations from Mr. J. R. Planché's "Recollections," Mr. John Hopkinson's lecture at the Institution of Civil Engineers, carry him over another quarter of a column. We then have a dissertation on the advantages of electric lighting over gas in foggy weather, and, to wind up, a series of prophetic utterances, into which Mr. Tennyson is dragged. He looks forward to the time when possibly "every nightfarer will carry his little ray of electricity about him, enclosed within the compass of a machine not larger than the watch now ticking in his pocket." There is hardly a sentence of original matter in the *Daily Telegraph's* article that does not betray an utter ignorance of its subject.

Earthquakes.—During the past week several earthquakes have been reported from different quarters of the globe. At Irkutsk, in Siberia, a slight shock was felt at 11:20 p.m., on the 9th instant. Several shocks were felt on the afternoon of the 10th inst. throughout the whole of Northern Moravia. The oscillations lasted on each occasion from one to two seconds. The most violent shock occurred at Olmütz. There a chimney fell and a man who was at work in a carpenter's shop was severely injured. The entire population of the city rushed from the houses into the streets, but there was fortunately no loss of life or any other damage of importance done. Telegrams from Cilli, in Southern Styria, show that there were severe shocks felt there about an hour earlier than at Olmütz. There was also a shock at Agram, on the 10th inst., lasting two seconds. On the following morning, Thursday, the 11th, a severe earthquake shook San Francisco. The *Daily News* correspondent says that "three hours earlier there had been a slight shock, which passed without general notice, but there was no mistaking the visit at one this morning. The houses rocked as if violently shaken by a strong hand. Windows rattled as if they would fall to pieces. The air was filled with a strange rushing noise, and an indescribable tremor shook the earth. This lasted several seconds, and wakening people suddenly from sleep, created widespread terror. I do not hear of any injury done. It is more than twenty years since anything approaching this was felt in San Francisco." A Reuter's telegram from Syra, dated October 15, says:—"A strong shock of earthquake, lasting fully eight to ten seconds, has been felt at Chios. A few old houses were destroyed, and several people were injured. Great panic prevails. The shock was felt at Syra, on the Dardanelles coast, and at Smyrna. Much damage, attended by loss of life, is also reported to have been done in the town of Aivalik, in Asiatic Turkey." A telegram to the Central News, dated Constantinople, Oct. 17, says:—"A fearful earthquake occurred yesterday (Tuesday) near Chesmeh, a small town on a peninsula on the coast of Anatolia, and about twelve miles from the island of Scio. It appears that the whole peninsula, from Smyrna to Chesmeh, together with the neighbouring island of Scio, was violently convulsed. The greatest destruction has been wrought in the western half of the peninsula, between Chesmeh and Voulra. All the villages in this district are destroyed, being nothing more than heaps of ruins. The wretched inhabitants had no time to escape, and upwards of one thousand, it is estimated, have perished, while many others are injured. At Chesmeh itself numerous houses were thrown down or otherwise damaged, and the destruction of property is enormous. No lives, however, were lost in the town, though several persons were hurt by falling buildings. Scio and Smyrna, forming, as it were, the opposite extremities of the region of disturbance, were also affected, but less violently. Some damage was done, but only of a slight character, and no harm to life or limb is reported."

Patents Taken Out in America.—Mr. C. J. Kintner, chief examiner in the Electrical Department of the United States Patent Office, has prepared a classified list of the applications for patents made in his department since its

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organisation, which is very interesting. We give this list below in a somewhat condensed form:—

Patents granted relating to electricity.	All to July, 1881.	July, 1881, to July, 1883.	July, 1882, to July, 1883.	Total.
Alarms, burglar	80	15	8	103
Annunciators	89	10	9	108
Applications, general	31	18	23	72
Applications, tools & machines	58	8	18	84
Batteries, galvanic	155	18	25	198
Batteries, secondary	4	2	52	58
Batteries, secondary applications	3	17	12	32
Batteries, thermal	—	3	2	5
Bells	37	2	4	43
Car brakes	19	8	9	36
Clocks	43	6	21	70
Conductors	149	45	72	266
Connectors	31	6	13	50
Electrolysis	192	7	6	205
Electro-magnets	39	5	1	45
Exploding	39	2	—	41
Gas-lighting	156	19	14	189
Indicators	39	14	10	63
Induction-coils	33	—	4	37
Insulators	107	5	8	120
Keys	42	10	8	60
Lightning-arresters	8	7	11	26
Lightning-rods	154	8	9	171
Lights—arc	94	102	131	327
Lights—incandescent	54	72	92	218
Lights—system and appliances	44	73	78	195
Magneto-electric	87	64	107	258
Magneto-electric hand machines	25	8	7	40
Meters	11	10	5	26
Motors	116	11	25	152
Railway signals	139	28	39	206
Recorders	28	8	10	46
Regulators	68	14	73	155
Relays and sounders	112	25	8	145
Repeaters	30	2	2	34
Telegraph poles	23	2	1	26
Telegraphs	46	5	3	54
„ automatic	111	10	8	129
„ dial	23	—	1	24
„ duplex	61	16	10	87
„ dynamo	8	1	3	12
„ fire	140	13	23	176
„ multiplex	7	2	1	10
„ perforating	26	—	7	33
„ printing	191	8	18	217
„ quadruplex	19	10	3	32
„ railway car	22	4	15	41
Telephonic telegraphs, calls	61	33	13	107
„ details	7	5	3	15
„ electric	102	50	33	185
„ magnetic	66	26	16	108
„ mechanical	22	10	13	45
„ radiophones	6	—	—	6
„ reed	30	1	2	33
„ relays and repeaters	4	7	1	12
„ systems	103	72	78	253
Underground lines	52	33	78	163

Mr. Kintner further tells us that of the patents taken out between July, 1882, and July, 1883, 109 were granted to Edison, 56 to Weston, and 23 to Brush.

Heat Changes at the Poles of a Voltameter.—Herr E. Edlund has made some researches in this direction, the results of which were communicated by him to the *Ann. Phys. und Chem.*, Second Series, Vol. 19, p. 287, &c. The following abstract of this article appeared in the *Journal of the Chemical Society* for August:—"In the year 1869 the author propounded the view that when a current passes through an electro-motor in the same direction as that of the electromotor, a quantity of heat disappears proportional to the product of the E.M.F. by the intensity of the current; conversely, if the current is in the opposite direction, an equal quantity of heat is produced. If in a closed circuit a current is formed of one or more E.M.F.'s, then these forces destroy a quantity of heat equal to the sum of the heats caused by the resistance of the circuit. The total heat production of the current is therefore *nil*, inasmuch as on the passage of the current through the circuit an amount of heat is produced equal to that required by the E.M.F. Sir William Thomson, however, considers that the sum of the heat evolved by the resistance is equal to the quantity of heat produced by the chemical changes within the battery; but if the author's view be accepted these quantities bear no intimate relation to one another. The author has carried on experimental investigations on this point, and has succeeded not only in establishing that his proposition satisfactorily explains the observed phenomena, but also in some cases he has calculated the value of the heat changes. His work has received further confirmation at the hands of J. Thomsen, Braun, and Hoorveg. In the present communication, the author proposes a method by which it is possible to decide whether the heat consumed by the E.M.F. is greater or less than that evolved by the chemical changes, without a separate estimation of the latter. Salts of copper, zinc, silver, cadmium, and lead were used as electrolytes, and the electrodes were of the same metal as that present in the salt Taking for example copper sulphate with electrodes of copper, and assuming a current of intensity i passed through, then the heat evolved from the resistance of the liquid is gi^2, where g is a constant. At the anode, copper sulphate is formed, and an amount of heat required, which can be expressed by ki, where k is a constant. But as the anode is the seat of an E.M.F., a quantity of heat is consumed, expressed by ei where e is the E.M.F. At the cathode, where copper is separated, there is a heat absorption equal to $-ki$, and therefore the sum of the heat changes at the anode is equal to $gi^2 + ki - ei$, and at the cathode, $gi^2 - ki + ei$. In experiment gi^2 must be eliminated, and the reading of the instrument made dependent on the difference between ki and ei, and the current must pass through the electrolyte only for a short time, in order to prevent any marked variation in the neighbourhood of the electrode. If the current be passed through an electrode A, then the rise of temperature at the point of junction with the circuit is equal to $f(gi^2 + ki - ei)$, where f is a constant, and at B is $f'(gi^2 - ki + ei)$ wher f' is another constant. If the rise of temperature is not the same in both cases, then the swing of the galvanometer is proportional to the difference between them, and so $f(gi^2 + ki - ei) - f'(gi^2 - ki + ei) = a$. If the current be reversed, so that B is the positive pole, then there is a different swing b in the galvanometer, so $f'(gi^2 + ki - ei) - f(gi^2 - ki + ei) = b$. Hence it follows that $ki - ei = \left(\frac{a+b}{2}\right)(f + f')$. If $a + b$ is positive, then the heat produced by the chemical change is greater than that consumed by the E.M.F.; if the sum is negative, then this relation is reversed. The author proves by his experiments, the details of which are given in the original paper, that in Daniell's cell the E.M.F. consumes an amount of heat equal to that produced by the chemical process. On the other hand, with solutions of silver nitrate and sulphate with silver electrodes, the E.M.F. between the metal and the salt solution consumes a greater quantity of heat than that set free in the formation of the salt, and therefore $\frac{a+b}{2}$ has a negative value; the same obtains with lead acetate and lead.

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ELEMENTARY ELECTRICITY.—XV.

The conduction of electricity in metallic conductors is analogous to the flow of water along a pipe or channel, while the transfer of electricity through electrolytes is a species of electric convection which may be compared to the conveyance of water in carts or similar conveyances, the carts corresponding to the dissociated atoms of the electrolyte. If the carts are of equal capacities, and all filled, each cart will carry the same quantity of water, and will in this respect resemble a dissociated atom of an ion which moves through the electrolyte, bearing with it a perfectly definite charge. The quantity of water which can be conveyed from one place to another in a given time by a given number of carts will of course depend on the forces employed in moving them, and the rate at which the transfer of electricity takes place through the electrolyte must, similarly, depend on the electromotive force acting on the ions; but if the force applied to each cart is given, it is clear that the rate at which the water can be transferred will be proportional to the number of carts employed on the job. Similarly, with a given electromotive force, the strength of the current will depend upon, and increase with, the number of dissociated atoms to be found in any given volume of the electrolyte. But this number increases with the temperature, for increasing the velocities of the moving particles must increase the number of shocks capable of producing dissociation. Hence the conductivity of electrolytes may be expected to increase with the temperature, and experiment proves that the conductivities of electrolytes increase at a rapid rate as the temperature rises. Thus, with dilute sulphuric acid of specific gravity 1·23, which corresponds to maximum conductivity, the rate of increase of conductivity per degree centigrade is about 1·3 per cent. As stated previously, the *resistance* of metallic conductors increases with the temperature.

As all the electricity which crosses an electrolyte has to be carried by the ions, and each atom carries a definite charge, we see at once a reason for Faraday's law of electro-chemical equivalents.

If a plate of copper and a plate of amalgamated zinc are dipped in dilute sulphuric acid and connected by a wire, a current flows round the circuit, the zinc is dissolved and hydrogen escapes, but the hydrogen is not evolved from the surface of the zinc; it passes through the acid and appears upon the surface of the copper plate. The copper plate thus becomes coated with a layer of nascent hydrogen. When the accumulation of gas on the plate is considerable, bubbles of ordinary hydrogen will be formed, and escape, and the rate at which such bubbles are formed increases with the amount of the gas accumulated on the plate. Hence, if a strong current is evolving hydrogen very rapidly, the amount to be found on the copper plate will be considerable, and increase somewhat with the current. The copper plate thus becomes polarised, like the platinum plates described above; it is practically converted into a hydrogen plate instead of a copper plate, and as the E.M.F. of a battery consisting of zinc and hydrogen plates dipped in sulphuric acid is much less than that of a zinc-copper couple, the E.M.F. of the battery is correspondingly reduced, while the resistance of the battery is increased on account of the layer of badly conducting hydrogen adhering to the copper plate. Thus, the polarisation of the plates of a battery reduces the E.M.F. of the battery, but increases its resistance.

Smee reduced the polarisation by replacing the copper plates with silver plates coated with finely divided platinum. This battery has a slightly greater E.M.F. than the copper zinc battery, and the particles of platinum projecting from the silver act as points, and assist the liberation of the gaseous hydrogen.

The essential feature of a so-called *constant* battery is that the E.M.F. is the same, whatever be the magnitude of the current flowing through it, that is, whether the resistance of the external circuit be great or little. It is, in fact, a battery which does not *polarise*. No batteries are absolutely constant. In experimenting with a certain one-fluid battery it was found that, when the resistance of the circuit was 10,000 ohms, the E.M.F. was more than 1·6 volt, but on reducing the resistance, and thus increasing the current, the E.M.F. fell, and when the resistance of the circuit was about 10 ohms the E.M.F. was reduced to 1·2 volt. There are many batteries in which the polarisation is much worse than this.

A battery which is so arranged as to work for a very long time without requiring to be replenished is very useful for many purposes, but must not be confounded with a *constant* battery properly so called. In all batteries the current depends on the E.M.F. of the battery, the resistance of the battery, and the resistance of the external circuit in accordance with Ohm's law, but in most cases (practically to some extent in all cases), if the resistance of the circuit is diminished so as to increase the current, it is found that the current does not increase in the same proportion as the resistance is diminished. This is due to a diminution of the E.M.F. of the battery accompanying the increase of current in consequence of the increased polarisation. In a *constant* battery this effect is supposed not to occur, but no one has yet succeeded in producing an absolutely constant battery. The effect is, however, very small in such batteries as Daniell's. In these batteries the E.M.F. is very nearly constant, whatever may be the strength of the current flowing through the cells. In order to render batteries constant, steps must be taken to prevent the polarisation of the plates by the deposition of hydrogen or otherwise.

Some one-fluid batteries have been constructed in which the hydrogen is employed at once in a secondary chemical action, and is thus prevented from accumulating on the metal plates. The bichromate battery is a good type of this class. It consists of plates of carbon and zinc, dipped in dilute sulphuric acid, but with the acid there is dissolved a quantity of potassic bichromate. The hydrogen, liberated by the solution of the zinc, reduces the bichromate, forming water and sesqui-oxide of chromium, and this and the liberated potash, combine with the sulphuric acid, forming chrome-alum. The hydrogen is therefore never liberated in the free state, but at once employed in reducing chromic acid.

A similar action occurs in the batteries of Grove and Bunsen, only nitric acid is employed for the absorption of the hydrogen, instead of potassic bichromate. It is obvious, however, that while in the bichromate battery the potassic bichromate may be mixed with the sulphuric acid, it would not do to allow the nitric acid of the Grove or Bunsen cell to reach the zinc plate. The nitric acid is therefore placed in a separate pot of porous earthenware, which is placed in the sulphuric acid. The nitric and sulphuric acids meet in the pores of the earthenware, but their diffusion is very slow. The amalgamated zinc plate is dipped in the sulphuric acid, while a platinum plate in the case of Grove's battery, or a carbon plate in the case of Bunsen's battery, is plunged in the nitric acid in the porous pot. The liberated hydrogen in its passage to the platinum or carbon plate meets with the nitric acid, reducing it to nitrogen trioxide (which gives the green colour to the spent acid), or to other lower oxides of nitrogen. It appears that nitrogen trioxide when anhydrous forms a deep blue liquid, but when diluted with water it loses its colour. When mixed with concentrated nitric acid the nitrogen trioxide is probably in the anhydrous condition, since the nitric acid holds all the water in combination, and nitric acid which has been used in Grove's and Bunsen's battery for a short time possesses a dark green colour. When the acid is diluted the colour disappears.

The most constant, as well as the earliest of the "constant batteries," is that of Daniell. In this battery the plates are zinc and copper. The zinc is plunged in dilute sulphuric acid, and the liberated hydrogen is employed in decomposing copper sulphate which surrounds the copper plate. In this way pure copper is deposited, instead of hydrogen, on the copper plate, and this does not sensibly alter the character of the plate, so that polarisation to any great extent is impossible. The electrical properties of the copper depend, however, to a slight extent on the rate at which it is deposited, and thus the E.M.F. of the battery is not absolutely constant, but the cell is by far the best of its kind. As the copper sulphate would deposit copper on the zinc if it could reach it, a porous pot is employed to separate the sulphuric acid and the copper sulphate.

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In an electrolytic cell chemical decomposition takes place, and work is done by the battery or other agent which sends the current through the cell, this work being equivalent to that done against chemical forces in producing decomposition. The least electromotive force capable of sustaining a current through the electrolyte is determined by the condition that it must be numerically equal to the work done in decomposing one electro-chemical equivalent of the compound. A battery cell may be regarded as the reverse of an electrolytic cell. In it a current is produced, the energy being supplied by the work done *by* chemical forces within the battery. For every unit of electricity passing round the circuit one electro-chemical equivalent of zinc must be dissolved, and other chemical action must take place, differing according to the nature of the battery. If we know the chemical actions which go on in the battery, the total amount of work done by chemical forces when one electro-chemical equivalent of zinc is dissolved can be determined. Hence a determinate amount of work will be done by chemical forces in the battery for every unit of electricity passing round the circuit, and since the work done on the current cannot be greater than the energy supplied by the chemical action, it follows that the electromotive force of the cell cannot exceed the number of units of work due to the chemical action which accompanies the solution of one electro-chemical equivalent of zinc.

For example, suppose a battery to consist of a simple zinc copper couple plunged in dilute sulphuric acid, for every unit of electricity passing round the circuit ·000333 gramme of zinc will be dissolved and ·0000105 gramme of hydrogen liberated. The amount of work done by the chemical forces can be determined by dissolving a known amount of zinc in dilute sulphuric acid, and allowing the hydrogen to escape, the whole operation being conducted within a calorimeter, by which the amount of heat produced can be measured. The mechanical equivalent of the heat, corresponding to the solution of ·000333 gramme of zinc, will represent the electromotive force of the battery.

Now, suppose a Grove cell employed, and the same amounts of zinc dissolved. Instead of the hydrogen being liberated, as in the previous case, carrying with it the energy which it has absorbed in being separated from its combination with oxygen, the hydrogen in the Grove cell is burnt at the expense of the oxygen of the nitric acid, and a corresponding amount of additional work is done by the chemical forces in the cell, the only work done *against* chemical forces being the separation of oxygen from nitric acid, and this requires very little work indeed. Hence, more work being done on the whole by the chemical forces in the Grove cell than in the cell above described, the electromotive force of the Grove cell is correspondingly greater.

In Daniell's cell the hydrogen liberated by the solution of the zinc is compelled to decompose copper sulphate, and instead of the hydrogen itself escaping free copper is deposited on the copper plate. Here the hydrogen is consumed as in the Grove cell, but instead of obtaining its oxygen by the decomposition of nitric acid, which involves very little work indeed, the hydrogen is obliged to decompose copper sulphate, liberating free copper, and this requires a great deal of work to be done, in fact, about half as much work as is done by the combination of the zinc with oxygen and sulphuric acid. Hence the electromotive force of Daniell's cell is little more than half that of Grove's cell.

In the bichromate battery comparatively little work is required in order to obtain oxygen from the potassium bichromate, and hence the electromotive force of the bichromate cell is nearly the same as that of Grove's cell.

In selecting a battery for any purpose the chief considerations to be borne in mind are—

1. Its electromotive force.
2. Its resistance.
3. The extent of its polarisation with the currents required.
4. Its liability to injury on account of the diffusion of the liquids employed in it.
5. The character of the gases or fumes emitted by it (if any).
6. Its prime cost and cost of maintenance.

The value of a battery will of course, *cæteris paribus*, be proportional to its electromotive force. If the battery is required to send a current through a circuit of small external resistance, it is important that the resistance of the battery should be small, but if the external circuit have a great resistance the resistance of the battery is of small consequence provided it is not nearly equal to that of the rest of the circuit.

In a battery which is required only to send brief currents, and has a long interval of rest between them, the question of polarisation is not of great importance. When it is required to maintain a steady current for a considerable time, a constant battery should be employed.

There are some batteries which are very constant, but which suffer injury if left to themselves, on account of the diffusion of the different liquids employed in their construction. For example, if a Grove battery be left charged for some hours, but with no current flowing through it, the nitric acid will gradually diffuse through the porous jar into the sulphuric acid and attack the zinc. While the battery is sending a current of moderate strength, the nitric acid is attacked and deoxidised by the liberated hydrogen before it can get through the walls of the porous jar. Hence, a Grove battery must be charged very shortly before using, and discharged as soon as it is done with.

In some Daniell cells a semi-saturated solution of zinc sulphate is used instead of sulphuric acid, and the zinc is not amalgamated. If these cells are left to themselves for a long time the copper sulphate diffuses into the zinc sulphate and attacks the zinc plate, coating it with copper, and thus destroying in great measure the efficiency of the battery.

THE ELECTRIC LIGHT AT THE LEEDS FESTIVAL.

(FROM OUR SPECIAL CORRESPONDENT.)

The electric light in its incandescent form has again proved its perfect suitability for illuminating great public assemblies, and its employment at the Leeds Town Hall for the musical festival, while putting a severe strain upon the resources of its purveyors, show how great those resources are, and what rapid progress has been made in the appliances for its production.

It has been for some time under consideration whether the electric light should be employed on this occasion, and several companies were applied to and sent in tenders; but for some reason the authorities hesitated in making up their minds, and allowed time to slip by, until the near approach of the date of the festival compelled a decision. Whether they thought that, like Owen Glendower, they could "call spirits from the vasty deep" to do their pleasure does not appear, but it is fortunate that the spirits upon whom they did call, being energetic, and possessed of the powers of materialisation, did come when they were called. Still, it is scarcely fair to engineers to be called upon to establish a large installation of this character with no longer notice than three weeks, which we are informed is the period between the opening of the festival and the first call upon the Crompton-Winfield Association to undertake the lighting. That they have done the work, and done it well, ought not to induce others in like case to run matters quite so close, when there is no really sufficient reason, because while municipal and other authorities may not appreciate the amount of work to be done, every one can find fault should anything be overlooked in the inevitable hurry.

The Victoria Hall is a handsome but somewhat heavily decorated building, having an arched roof formed of shallow ribs, with carved panel work between them, supported upon side arches carried by pairs of projecting pillars; at one end a curved recess of the full height of the building is formed by a deeper rib, carried by four pillars at each side. This recess, in which the fine organ stands, forms a parabolic reflector behind the orchestra, and has no doubt a good deal to do with the good acoustic properties of the hall; a deep gallery crosses the further end of the hall, the construction of which does not, therefore, favour the division of lights. The plan

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adopted, and probably the only one suited to the structural conditions, was to suspend seven pendants from the arched ribs of the roof, three in the middle line, and four towards the corners, so as to ensure an equal distribution of light as well as an effective appearance, this latter being, of course, an important consideration.

These pendants illustrate the artistic capacity of the incandescent light, fitted up at the utmost pitch of speed. Elaborate workmanship was out of the question. Nothing is used in them but plain hoops and simple brass tubing, yet they are as effective as if built up of the most elaborate metal work. The truth is evident that the dazzling points of light, when canopied, shaded, and enlarged by the tinted glass covers, are sufficient in themselves; a tasteful arrangement of their lines and groupings is all that is necessary to satisfy the eye. This is obtained by rings of lamps rising in a cone from a single lamp, each ring varying in distance from the others, as do the lamps in each ring. There are 56 lamps in each pendant arranged two in series, and connected together by wires in the tubes, led up to a central plate at the top. They are suspended by steel wires passing through holes in the arched ribs of the ceiling in the centre of ornamental points, so that they can be lowered whenever required, connection being made through loose cables hanging by the side of the supporting wires. The effect is as though the lights were self-supported.

The lamps themselves are of the latest Swan pattern, of 160 ohms hot resistance, and working with a current of about ampere 0·65, giving 20 candle-power.

The engine and dynamo machines are stationed in a street about 300 yards distant, and the circuit between them and the hall is made by a number of cables of seven No. 16 wires, all inserted in one iron pipe provided by the gas department.

Under the exigencies of the case it was necessary to employ such machines as happened to be in readiness, and it was found better to use independent machines and circuits for each pendant, and for a row of 56 lamps under the gallery, which make up eight distinct sets. There are therefore nine dynamos provided, of the C pattern of the well known Crompton-Bürgin machine, as nearly alike as the circumstances allowed; but at this stage they all blend into one driving system, and are connected separately to a commutating system by which any dynamo can be used to either of the circuits and their working condition tested at any instant. They work with an average E.M.F. of 240 volts, and give an average current of 17·5 amperes to each of the eight circuits.

The driving arrangement consists of a massive countershaft carrying nine driving pulleys for the several dynamos, which are therefore arranged on a floor in front of this shaft in two diagonal sets, each machine fitted with its set screw for adjusting the tension of the belts. This countershaft is itself driven by two pulleys and belts, one from each side of the engine shaft, an arrangement which secures steadiness in driving, each counteracting any little irregularities of the other.

The engine itself is, of course, a most important element, and one of some difficulty in such a case, and a difficulty which only those acquainted with the subject would perceive, because they alone can know that perfect steadiness is the most important consideration, and that as an engine capable of working up to 200 horse-power is required to secure that wide margin of force over work which is essential to the quiet, steady exertion of power, a perfectly stable foundation is required.* This requirement, not easy to satisfy when a piece of bare ground has to be fitted up for the purpose, engine and dynamos erected, and even the roof over them built in a few days, is met by employing an engine constructed by Messrs. John Fowler and Co., of Leeds, who make this type for the Crompton-Winfield Association, but have themselves supplied and worked this engine as their personal contribution to the festival.

This engine meets the foundation difficulty by having its own foundation in the form of one massive casting, which carries the whole structure. The fire-box at one end, on the locomotive type, with tubes, beneath which are the cylinders at the further end, and the main shaft bearings in the middle, equally carried by projections forming part of the foundation. Therefore, all that is required is something firm and solid for the casting to rest on.

The engine is a compound one, with two cylinders and their pistons connected to the cranks, so as avoid dead points and be self starting, while to assist the starting the cylinders are at first supplied by steam direct from the boiler, and as soon as the initial resistance is overcome one cylinder takes the steam direct from the boiler, exhausting into the second cylinder, in which the full expansion takes place. The engine works with great steadiness, and the pressure gauge shows no motion, the power being transmitted with little variation.

The total result is a perfect success, the lighting being in every way satisfactory, and notwithstanding the pressure under which the work was effected the whole operation has gone on with but a single temporary and slight hitch, which deserves mention because the circumstances under which it occurred were extra creditable to the contractors and their staff; while the mere fact of its occurrence unexplained might be interpreted as a defect in the arrangements, and an instance of unreliability in the light itself.

The contractors undertook (notwithstanding the short time available) to light the hall at seven o'clock on Wednesday evening. At eleven o'clock on Wednesday morning, while the engine room was being cleaned and whitewashed, and the dynamos were being tested, a dense fog overspread the city, and there was a prospect of the first morning performance being conducted by an orchestra invisible to the audience. Messrs. Crompton and Winfield and their staff came to the rescue, rapidly got things into order, and lighted up the hall eight hours before their time, and with only the slight lowering of the light for a few minutes in consequence of the discovery that a bearing was becoming undesirably warm, no doubt owing to a little grit which had got into it during the hurry of the unexpected clearing up.

* In this instance extra large power was required, not only for the actual lighting now described, but also to be prepared for working some powerful arc lamps to be used outside the Town Hall in a short time during Mr. Bright's visit to Leeds.

SUBMARINE MINES.

(CONTINUED FROM PAGE 442.)

The Wheatstone Exploder.—This instrument, which appeared about the year 1860, was the earliest magneto-electric machine destined to be extensively introduced in practical blasting. It was a successful modification of apparatus simi-

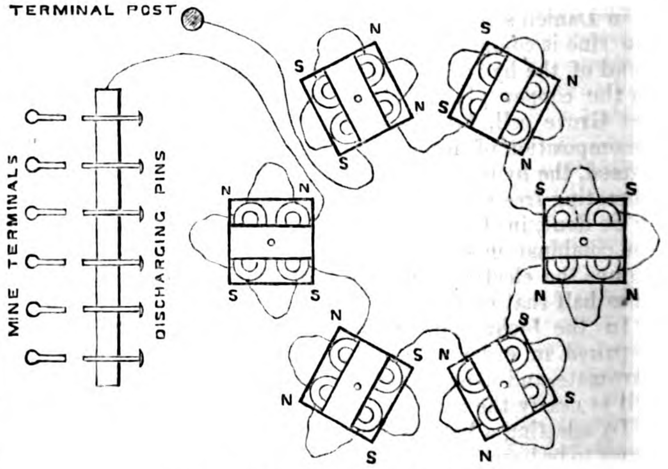

FIG. 4.—The Wheatstone Exploder.

lar to that already described, and was designed to replace the single wave by a very rapid succession of currents alternating in direction. These currents, thrown at will into the exterior circuit containing the fuses, increased the certainty and the possible number of explosions.

The perfected machine (Fig. 4) consists of six seven-plate

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permanent horse-shoe magnets, so disposed around a central brass axis, in a stout case, as to bring all the poles upon the circumference of a vertical circle. To each pole are attached two soft iron rods, each wound with fine insulated wire, No. 23, B.W.G. The twenty-four coils are all united in series, and the ends are attached to exterior terminal plates. The joint resistance of the interior circuit is 8,400 ohms, or 350 ohms to each coil.

One of the terminal plates is to be put to earth; the other carries six movable firing pins. When a pin is depressed it closes the circuit between the plate and one of six insulated binding posts designated to receive the leading wires from a set of six mines. The full speed of revolution can thus be gained before closing the circuit; and the desired charge, or group of charges, can be exploded without endangering any of its five neighbours and without shifting leading wires.

The variation in the magnetic strength of the soft iron cores, upon which the generation of the current depends, is effected by revolving six soft iron armatures rigidly attached to separate shafts geared to a common central axis which is moved by a crank. One revolution of the latter causes six revolutions of each armature, and a high speed is thus secured.

The armatures revolve in close proximity to the exposed ends of the rods forming the cores of the coils. The four coils belonging to each magnet are disposed at the angles of a square, with the shaft of the armature in the middle. The width of the armature is such that at the instant when it leaves one core it reaches the next. The winding is so arranged that the current induced by leaving one set of diagonal cores is in the same direction as that induced by approaching the other diagonal set. The whole circuit is thus traversed by two negative and two positive equal currents during each revolution of the armature. As the six magnets are similarly wound, they unite to strengthen these currents, of which there are, of course, twenty-four at each revolution of the crank; great uniformity and rapidity is thus secured.

It is found, practically, in instruments of this class, that better results are obtained by periodically short circuiting the cores. Wheatstone effects this by attaching one terminal wire to the metallic axis of the instrument, and the other to an insulated spring. The latter presses on an ebonite cover fixed upon one of the armatures. Once in each revolution of the latter, the spring touches a platinum pin connected with the armature, and thus with the axis of the instrument. The case is 12in. by 11in. by 12in., and has a total weight of 58 pounds. The crank handle is much too short for convenience. The available potential is not sufficiently high to allow many fuses to be coupled in series, and a simple derived circuit should therefore be employed. Only tension fuses possessed of considerable conductivity can be exploded by the machine.

A series of careful experiments conducted by the British Government, and fully reported in Vol. X, New Series, *Professional Papers* of the Royal Engineers (1861), exhibit the following results:—Employing the Abel fuse and a derived circuit, from twelve to twenty-five charges at 600 yards from the machine can be exploded on land, and four under water. A single fuse has been exploded through over 100 miles of land telegraph wire. Insulation must be carefully secured; and the explosions in derived circuits are not absolutely, although very nearly, simultaneous.

Although this is a neat, ingenious, and serviceable instrument, it is now superseded, at least in this country, because it can be used neither with low tension nor very high tension fuses.

The Beardslee Machine.—This instrument, patented in 1859 and 1863, is similar in principle to that of Wheatstone, but is larger and more powerful. It was much used during our late civil war, in which it justly won a high reputation; but it is now superseded by later devices, for the same reason as the Wheatstone exploder.

The machine (Fig. 5) derives its power from a Stellar cast-iron magnet, having ten poles radiating from the centre, and alternating in polarity. The axis is central, and perpendicular to the horizontal plane of the magnets, and is so geared as to admit of rapid revolution, four turns of the magnet to one of the crank. To insure solidity, the spaces between the magnets are sometimes filled by wooden wedges, the whole bound together by a brass tyre.

Immediately under this magnet is placed a soft iron ring of equal diameter. Ten pins of soft iron rise from this ring, so placed that when one is covered by a magnet pole all the others are so likewise. These pins are the cores of coils of moderately fine insulated wire, each having a resistance of 110 ohms. As the crank is revolved, the motion of the magnet poles causes a rapid reversal of polarity in the cores, and thus generates a succession of alternating currents of electricity in the coils. The latter may easily be coupled, as desired, to produce high or low potential—*i.e.*, in a continuous series for high, and in multiple arc for low potential. The usual arrangement is two groups of five coils each. Convenient terminal posts are arranged to receive the leading wires, and a switch is added to allow a high speed of revolution before sending the current into the exterior circuit containing the fuse.

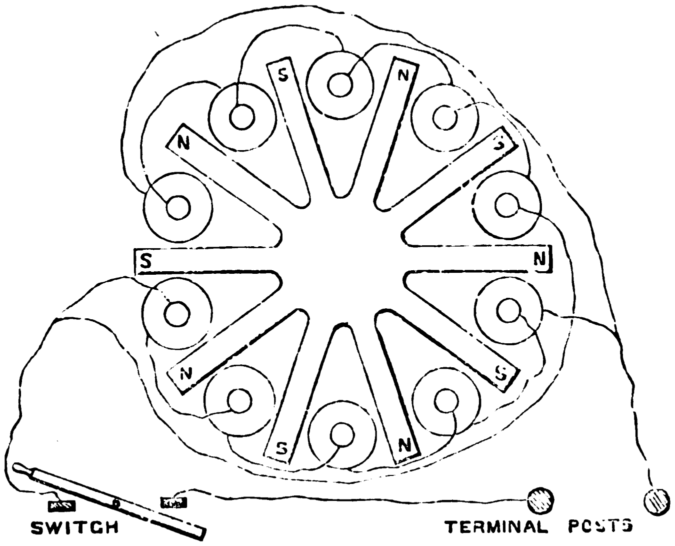

Fig. 5.—The Beardslee Machine.

The apparatus is held together by a stout iron frame, permanently encased in a box 18in. by 18in. by 14in., weighing 115lb. Like other instruments of its class, the Beardslee machine exacts a certain conductivity in its fuse. The Abel explodes readily with it, and Captain Beardslee, son of the inventor, has devised a special type, consisting essentially of a lead pencil mark connecting the leading wires. Fine powder packed on this line is ignited by the heat developed by the electricity. This fuse is claimed to have been fired by the machine at a distance of 240 miles through an ordinary telegraph line. In submerged cable the range is of course far less.

In fine, Beardslee's machine is a strong, serviceable instrument, little likely to get out of order; but it is too heavy, and it cannot be used with the best fuses now in the market in this country.

(TO BE CONTINUED.)

Joint Stock Companies.—The Registrar of Joint Stock Companies has given notice that, unless cause is shown to the contrary, the following will be struck off the register within three months:—Anglo-Australian Telegraph Company, Calcutta and Singapore Telegraph Company, Franco-Egyptian Telegraph Company, Home and Foreign Telegraph News Company; India, Australia, and China Submarine Telegraphs (Limited); International South-Transatlantic Telegraph Company, Jersey and Guernsey Telegraph Company, London and New York Telegraph Company, Manila and Hong Kong Submarine Telegraph Company, National Telegraph Manufacturing Company, New York and London Direct Telegraph Company, Ocean Telegraph Company, Telegraph Factory and Maintenance Company.

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LITERATURE.

Practical Electrical Units Popularly Explained, with numerous Illustrations and Remarks. By JAMES SWINBURNE. [E. and F. N. Spon].

This little book will be found to be of use. It explains the various mechanical and electrical units in use clearly and concisely, and although we cannot entirely agree with the hasty adoption of some of these units, that does not detract from the value of the explanations. In our schoolboy days we used to admire the—what seemed to us—intense common sense of the Greeks and Germans, who, when at a loss for a word to express their meaning, coined one, or compounded one from separate words expressing that meaning. Thus the foot-pound has always found favour in our eyes, as has the volt-ampere, and we hesitate to adopt another word for foot-pound as we hesitate to adopt the term suggested for volt-ampere. The compound defines itself, the new term needs a definition. These remarks apply also to other terms recently introduced. Fancy talking about a megjoule—a term no doubt correct according to the notation and nomenclature adopted, but not euphonious, and we have reason to suspect that euphony will play its part in naturalising in the language any term that may be suggested. We are not sure that we agree with the author in his remarks on page 27, chap. III., relating to "Current" and "Electricity;" we are, indeed, not quite sure that he understands what he is driving at himself. With one or two exceptions, the author gives no credit to the men who first suggested the ideas he has embodied in this work. These adverse remarks will be seen not to apply so much to the author's work—for, as we have previously said, that is useful—as to the notation and nomenclature adopted.

A HISTORY OF ELECTRIC TELEGRAPHY TO THE YEAR 1837.

BY J. J. FAHIE, MEMB. SOC. TEL. ENGS. AND ELECS.*

NOTE.—Being anxious to make his History as complete as possible, the Author will be grateful to his readers for any information, no matter how small, in relation to the subjects treated of in these pages.

CHAPTER IV. (CONTINUED FROM PAGE 478).

The stupor of the arm lasted upwards of a quarter of an hour, nor could I afterwards think of the accident without emotion. I had no idea that such an animal was electrical; but in this I had the positive proof of experience."†

Galvani's great discovery is popularly supposed to have resulted from an accidental observation on frogs made in 1790; but as early, at least, as 1780, he was engaged, as we learn from Gherardi, his biographer, in experiments on the muscular contractions of these animals under the influence of electricity.‡

One day in that year (November 6), while preparing "in the usual manner" a frog in the vicinity of an electrical machine with which some friends were amusing themselves, he observed the animal's body to be suddenly convulsed. Astonished at this phenomenon, and supposing that it might be owing to his having wounded the nerve, Galvani pricked it with the point of his knife to assure himself whether or not this was the case, but no convulsion ensued. He again touched the nerve with his knife, and, directing a spark to be taken at the same time from the machine, had the pleasure of seeing the contortions renewed. Upon a third trial the animal's body remained motionless; but observing that he held the knife by its ivory handle, he grasped the metal, and immediately the convulsions took place each time that a spark appeared.§

After a number of similar experiments with the machine, Galvani resolved to try the effect of atmospheric electricity, and with this object erected a lightning conductor on the roof of his house to which he attached metallic rods leading into his laboratory. These he connected with the nerves of frogs and other animals, and fastened to their legs wires which reached to the ground. As was anticipated, the animals were greatly convulsed whenever lightning appeared, and even when any storm-cloud passed over the apparatus. These experiments were continued in 1781 and 1782, and were afterwards embodied in a paper (not published) "On the Nervous Force and its Relation to Electricity." In 1786, he resumed the inquiry with the aid of his nephew, Camillo Galvani, and it was in the course of these studies that certain facts were observed which led immediately to the discovery of galvanism.

One day (the 20th) in September, 1786, Camillo Galvani had prepared some frogs for experiment, and had hung them, by an iron hook, from the top of an iron rail of the balcony outside Galvani's laboratory to be ready for use. Soon he noticed that when, by accident, a frog was pressed, or blown, against the rail the legs contracted as they were wont to do when excited by the electricity of the machine, or of the atmosphere. Surprised at this effect where there was apparently no exciting cause, he called his uncle to witness it, but Galvani dismissed it on the easy assumption that the movements were connected with some unseen changes in the electrical state of the atmosphere. He soon, however, found that this was not the case, and, after varying in many ways the circumstances in which the frogs were placed, at length discovered that the convulsions were the result of the simultaneous contact of the iron with the nerves and muscles, and that the effect was increased by using a combination of different metals—such as iron and silver, or iron and copper.

Galvani, who was an anatomist first and an electrician afterwards, accounted for these effects by supposing that in the animal economy there exists a natural source of electricity; that at the junction of the nerves and muscles this electricity is decomposed, the positive fluid going to the nerve, and the negative to the muscle; that these are, therefore, analogous to the internal and external coatings of a charged Leyden jar; that the metallic connection made between the nerve and the muscle serves as a conductor for these opposite electricities; and that, on establishing the connection, the same discharge takes place as in the Leyden experiment. Galvani's researches were not made public until the year 1791, when they were embodied in his celebrated paper printed in the Bolognese *Transactions* of that year.

It will be evident from this account, which is based upon the researches of Gherardi, Galvani's biographer, supported by original documents, how absurd is the popular story, first invented by Alibert in his *Eloges historiques de Galvani* (Paris, 1802), and constantly repeated since, that "this immortal discovery arose, in the most immediate and direct way, from a slight cold with which Madame Galvani was attacked in 1790, and for which her physician prescribed the use of frog-broth." As if frog-broth were usually prepared in the laboratory!

Luigi Galvani was born at Bologna on the 9th of September, 1737, and died there December 4, 1798. From his youth he was remarkable for the ardour with which he prosecuted his studies in anatomy and physiology, and at the early age of twenty-five he was appointed professor of these sciences in the University of his native place.

The closing years of his life form a sad contrast to those of his great contemporary, Volta, who died, in 1827, covered with honours.* At the moment when Galvani was immortalising his

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* The author reserves all rights of translation.

† Volta, in telling this story in after years, used to say that Cotugno was a pupil of Galvani, and that it was his drawing his master's attention to the phenomenon that put Galvani on the trail of his great discovery. (Robertson's "Mémoires Récréatifs Scientifiques et Anecdotiques." Paris, 1840, Vol. 1, page 233.

‡ From two papers in the *Bolognese Transactions*, one, "On the Muscular Movement of Frogs," dated April 22, 1773; and the other, "On the Action of Opium on the Nerves of Frogs," dated January 20, 1774, it is evident that Galvani's acquaintance with frogs was long anterior even to the year 1780. We follow mainly, in our account of Galvani's researches, Professor Forbes' Dissertation (Sixth), Chapter VII., in the "Encyclopædia Britannica," 8th edition.

§ These experiments are similar to, and are explained by, the phenomenon of the *lateral shock*, or *return stroke*, first observed by Wilson, of Dublin, in 1746, but first explained by Lord Mahon in 1779. In Galvani's experiment the frog, while it merely lay on the table, so being insulated, had its electricities separated by induction at every turn of the machine, and on the passage of every spark their reunion took place, but with so small effect that it escaped notice. When, however, the animal was placed in connection with the ground, through the knife and body of the professor, one of the separated electricities freely escaped, thus rendering a greater inductive charge possible, and raising the "return stroke" to a sufficient strength to convulse the dead limbs. It is but fair to add that Galvani himself suggested this explanation some years later.

* Alessandro Volta was born at Como, February 19, 1745. Soon after his discovery of the pile, in 1801, he was invited to Paris, and was honoured with the presence of the First Consul while repeating his experiments before the Institute. Bonaparte conferred upon him the orders of the Legion of Honour, and of the Iron Crown, and he was afterwards nominated a count, and senator of the kingdom of Italy. At the formation of the Italian Institute, a meeting was held, at which Bonaparte presided, for the purpose of nominating the principal members. When they were considering whether or not they should draw up a list of the members in an alphabetical order, Bonaparte wrote at the head of a sheet of paper the name of Volta, and, delivering it to the secretary, said, "Do as you please at present, provided that name is the first." At his death on March 5, 1827, his fellow citizens struck a medal, and erected a monument to his memory; and a niche in the façade of the public schools of Como, which had been left empty for him between the busts of Pliny and Giovio, natives of the town, was filled by his bust.

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name, he was obliged to undergo the most cruel blows of destiny; for he lost his dearly loved wife, Lucia Galeazzi, and, a short time afterwards, had the misfortune to be ordered by the Cisalpine Republic to take an oath which was entirely opposed to his political and religious convictions. He did not hesitate a moment, but promptly refused, and permitted himself to be stripped of his position and titles. Reduced nearly to poverty, he retired to his brother's house, and soon fell into a state of lethargy from which he could be aroused, neither by medicine, nor by the decree of the government, which, out of respect for his celebrity, reinstated him in his position as professor of anatomy in the University of Bologna. The great physicist died without having again occupied the chair which he had rendered so illustrious.

In 1879, the city of Bologna erected a statue in his honour, from the chisel of Adalbert Cincetti, the eminent Roman sculptor. It represents him at the moment when the muscles of the frog are revealing to him the effects of electricity on the animal organism.

Galvani's theory fascinated for a time the physiologists. The phenomena of animal life had hitherto been ascribed to an hypothetical agent, called the *nervous fluid*, which now Galvani's discovery had consigned to oblivion. Electricity was, henceforth, the great vital force, by which the decrees of the understanding, and the dictates of the will, were conveyed from the organs of the brain to the obedient members of the body.

Alexander Volta, then Professor of Physics at Pavia, and already well-known for his researches in electricity, had naturally his attention directed, in common with other philosophers, to the Bolognese experiments, and, although at first he warmly espoused Galvani's opinions, his superior sagacity soon enabled him to detect their want of basis. He first ascertained that the contractions of the frog ensued on simply touching, with the extremities of the metallic arc, two points of the same nervous filament; he next found that it was possible with the metallic arc to produce, either the sensation of light, or that of taste, by applying it to the nerves of the eye and tongue respectively.* In short, he ended by showing that the exciting cause was nothing more nor less than ordinary electricity, produced by the *contact* of the two metals, the convulsion of the frog being simply due to the passage of the electricity so developed along the nerves and muscles.†

The first analogy which Volta produced in support of his *theory of contact* was derived from the well-known experiment of Sulzer, which we have just described in these pages. From that it is seen that if two pieces of dissimilar metal, such as lead and silver, be placed one above, and the other below, the tongue, no particular effect will be perceived so long as they are not in contact with each other; but if their outer edges be brought together, a peculiar taste will be felt. If the metals be applied in one order, the taste will be acidulous. If the order be inverted, it will be alkaline. Now, if the tongue be applied to the conductor of a common electrical machine, an acidulous, or alkaline, taste will be perceived, according as the conductor is electrified positively, or negatively. Volta contended, therefore, that the identity of the cause should be inferred from the identity of the effects; that, as positive electricity produced an acid savour, and negative electricity an alkaline, on the conductor of the machine, so the same effects on the organs of taste produced by the metals ought to be ascribed to the same cause.

In August, 1796, Volta arranged an experiment which, by eliminating the physiological element, afforded, as he thought, a direct and unequivocal proof of the correctness of his hypothesis. He took two discs, one of copper and the other of zinc, and, by means of their insulating handles, carefully brought them into contact and suddenly separated them without friction; then, on presenting them to a delicate condensing electroscope, the usual indications of electricity were obtained, the zinc being found to be feebly charged with positive, and the copper with negative, electricity.

Of the numerous philosophers in every part of Europe who took part in the discussions, and varied and repeated the experiments connected with these questions, one to whom attention is more especially due was Fabroni, who, in the year 1792, communicated his researches to the Florentine Academy. In this paper is found the first suggestion of the chemical origin of galvanic electricity.

Fabroni supposed that, in the experiments of Galvani and Volta, a chemical change was made by the contact of one of the metals with the liquid matter always found on the parts of the animal body; and that the immediate cause of the convulsions was not, as supposed by Galvani, due to animal electricity, nor, as assumed by Volta, to a current of electricity emanating from the surface of contact of the two metals, but to the decomposition of the fluid upon the animal substance, and the transition of oxygen from a state of combination with it to combination with the metal. The electricity produced in the experiments Fabroni ascribed entirely to these chemical changes, it being then known that chemical processes were generally attended with sensible signs of electricity. (*Journal de Physique*, Vol. 49, p. 348.)

Galvani's theory was soon rejected on all hands, but a bitter war raged for a long time between the partisans of the contact theory of Volta and of the chemical theory of Fabroni. Now, however, it is generally conceded that both contact between dissimilar substances, and chemical action are necessary to produce the effect. "Perhaps," says Fleeming Jenkin, in his excellent little text-book, "it is strictly accurate to say that difference of potential is produced by contact, and that the current which is maintained by it is produced by chemical action."*

In pursuing his inquiries on galvanic electricity, Volta felt the necessity of collecting it in much greater quantities than could be obtained from the combination of a single pair of copper and zinc plates as above described, and he, therefore, sought for some means by which he could combine, and, as it were, superpose two or more currents, and thus multiply the effect. With this object he conceived the idea of placing alternately, one over the other, an equal number of discs of copper and zinc; but he found that the effect produced was no greater than that of a single pair, and for reasons which he was not slow to perceive. With such an arrangement as that described there would proceed, according to Volta's own theory, from the first surface a negative downward and a positive upward current, from the second a positive downward and a negative upward current, and from the third a negative downward and a positive upward, and so on. The downward currents would be alternately positive and negative, and the same would be the case with the upward currents; and since the surfaces of contact were equal all the *intermediate* currents would neutralise each other, and the effect of the pile would simply be that of the two extreme discs.

Volta, therefore, saw the necessity of adopting some expedient by which all the currents in the same direction should be of the same kind, and, if this could be accomplished, it was easy to see that the resulting currents, negative at the bottom and positive at the top, would be as many times more intense as there were surfaces of contact. To effect this it was necessary to destroy the galvanic action at all those surfaces from which descending positive and ascending negative currents would proceed; but while this was being done it was also essential that the progress of the descending negative and ascending positive currents should still be uninterrupted. The interposition of any substance, which would have no sensible galvanic action on either of the metals between each disc of copper and the disc of zinc immediately below it, would attain one of these ends, but in order to allow the free progress of the remaining currents in each direction, such substance should be a sufficiently good conductor of electricity. Volta selected, as the fittest means of fulfilling these conditions, discs of wet cloth, which would give rise to no galvanic action, while their moisture would endow them with sufficient conducting power.

Although the principle of the pile was thus evolved as early as the middle of 1796, Volta does not appear to have actually constructed the instrument with which his name has become so imperishably associated until some three years later, and it was not until the 20th March, 1800, that he published a description of it in a letter to Sir Joseph Banks, President of the Royal Society. In this letter he thus writes:—"I took some dozens of discs of copper, brass, or better, of silver, one inch in diameter (coins for instance), and an equal number of plates of tin, or, what is much better, of zinc. I prepared also a sufficient number of discs of card-board, leather, or some other spongy matter capable of imbibing and retaining water, or, what is much better, brine. I placed on a table a disc of silver, and on it a disc of zinc, then one of the moist discs; then another disc of silver, followed by one of zinc, and one of card-board. I continued to form of these several stages a column as high as could sustain itself without falling."

(TO BE CONTINUED.)

* These observations were independently made in England about the same time (1793): the one by Fowler, and the other by Professor Robison, of Edinburgh. The latter employed a number of pieces of zinc and silver made up into a *rouleau*, which, he thought, when rubbed along the tongue would increase the effect. In this contrivance Volta's pile is distinctly foreshadowed. See Bostock's "Account of the History and Present State of Galvanism," London, 1818, page 9.

† Volta first broached his contact theory in two letters to Cavallo, dated October, 1792. See *Philosophical Transactions*, 1793; also Chapters X. and XIII., Vol. 1, of Robertson's *Mémoires Récréatifs*, Paris, 1840, for much interesting information on the early history of galvanism. Robertson was a celebrated aeronaut, a friend of Volta, and one of the founders of the Galvanic Society of Paris early in the present century.

* This theory was, we believe, first propounded in England by Humphry Davy in 1806, see Lardner's "Electricity, Magnetism, and Meteorology," Vol. 1., page 164.

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THE ELECTRICIAN.

TO CORRESPONDENTS.

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OUR TELEPHONE SYSTEM.

Whatever may be the theoretical objections to a State-managed system of public service, it has one practical merit which private enterprise cannot lay claim to—it is bound to do its best. Private enterprise is bound to do no such thing; first and foremost it must do the thing that pays—not necessarily the thing that will pay in the long run, but what will pay quickest, with the possible result of one day not paying at all. Then it is pressed by the exigencies of competition; it must cover the most ground in least possible time, so as to block all intruders, and this results in work prematurely hurried forward, bad both in design and execution. With no eye except for immediate requirements, or for the demands of its shareholders, a system worked solely for profit is especially liable to those disastrous consequences which are afterwards ascribed to want of foresight. In truth, they are the invariable result of uncontrolled competition. We have seen the mischief of that system even in the case of our railroads, which, though partially controlled, were never intelligently guided with a view to the final requirements of the nation, and, to compare small things with great, we are seeing the same sort of process going on altogether uncontrolled in our telephone system.

The paper read by Mr. Preece at the last meeting of the British Association was instructive in several respects, though it contained nothing particularly startling. It was a plain business-like account of what the State—that is to say, the Post Office Telegraph administration—had been doing in the way of providing an efficient system of telephony. Some people may be surprised that the Post Office has not done more than it has done in quantity; but it will surprise no one that the quality is of the very best. After the adjustment of the dispute between itself and the telephone companies the Post Office appears to have let them proceed with the work they had in hand unmolested, and has contented itself with entering upon areas which the companies had either neglected or had only partially served. After reading the Government officer's report—for so in a sense it may be regarded—one cannot help saying happy is the place that the telephone companies despised. The companies themselves may be thankful the moderation of their formidable rival has left them in undisturbed possession of such places as London; but if Londoners compared notes with the people, say, of Newcastle, we suspect they would not share the companies' gratitude.

The practical system described by Mr. Preece as in active operation in the towns taken in hand by the Post Office is an ideally perfect system as well. There is evidence of caution, of deliberation, of careful planning, and of organisation; and, lastly, due attention has been paid to the contingent extension of the system. The wires are sufficient in number, or can be augmented without difficulty; they can be tapped in directions where branches are likely to be called for; they are all laid underground, and they are free from induction. In short, a wise calculation has been made beforehand, based, not upon what may be demanded at the moment, but on what will probably be required. The apparatus is on a par with the wiring. The instrument in use is of uniform pattern, and the best, probably, that has yet been devised by combining the meritorious portions of several inventions. And, finally, the signalling arrangements are as perfect as money and ingenuity can make them. If the public had a choice in a matter of this sort there is very little doubt as to where their choice would fall. On almost all points the State-managed system would outstrip any system we yet know of managed on commercial principles.

Now, we are not prepared to suggest that the public should at once be allowed the choice referred to; in other words, that the Post Office should enter into competition with the companies in London and elsewhere; though, if unrestrained competition is good for anything, it is good for that form of competition especially, because it would compel all competitors to rise to the level of the official model, and the public would be vastly the gainers, which is supposed to be the end and aim of free competition. Besides this, we have no wish at present to see the companies' interests suffer by reason of indiscretions which, all the circumstances considered, are pardonable. We say at present; but what may be forgiven of the past will not be condoned for ever. They must mend their ways, or else, even though the Post Office may continue forbearing, the public will not. Already there are plenty of signs that the public temper is not very friendly towards the telephone companies; and we may be sure that if they were doing their work as efficiently as their customers have a right to expect, public feeling would be entirely on the side of the vendors. The outcry against overhead wires would hardly be as loud and persistent as it is if the service rendered in return were deemed an adequate set-off against the annoyance. Then, again, there is local competition springing up afresh in formidable shape, and we are led to suspect there must be something wrong about a tariff of charges

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which tempts a competitor to reduce it by 50 per cent. We altogether deprecate such competition as that; but we do say it speaks ill for existing administration when competition of the kind is deemed practicable.

In defiance of all warning, however, the telephone companies pursue their reckless course with seemingly no guiding principle but the exigence of the moment, or the forthcoming shareholders' meeting. Their overhead wires have assumed proportions which constitute them a public danger as well as a national disgrace, a great portion of the city being rendered, we will not say hideous, but ridiculous by their presence. It is plain to be seen that these countless wires and cables have been erected without any system whatsoever, but are as erratic in their course and as impertinent in their intrusion as summer cobwebs drifting on the breeze. Less than half of their present number would suffice if erected on any rational plan; and, if we must have overhead wires, surely it would be cheaper, as well as more decent, to band them together cablewise, crossing the streets at right angles and as rarely as possible, rather than to work with the limited appliances of a spider, and without any of his brains. The haphazard crossing of wires gives rise to bad working, and in some localities it will soon become possible to overhear everybody's conversation but the person one really wants to hear. Nothing has been done to overcome induction, and to attempt it now would involve an extravagant outlay. The apparatus is miscellaneous, and in some instances a long way from being the best, so that customers very often find themselves in front of an instrument they do not know how to use. The boon conferred upon the commercial classes by the rapid extension of telephonic communication is undeniably very great; but it has been hurried forward in such a fashion that disappointment is very close at hand. Instead of being compelled, as a State-managed business would be, to give the public the very best service possible, these private companies have run up a system as bad as could well be devised, and one that is certainly doomed to fail.

ALFRED NIAUDET.

Death has indeed been busy in the electrical world this year. It is but a few weeks since Cromwell Varley and Richard Werdermann were taken away, and now the melancholy duty devolves upon us of recording the death of Alfred Niaudet. M. Niaudet was a member of the well-known firm of Breguet, of Paris, and in this capacity made the acquaintance of many of the best known electricians and inventors of the day, both in France and England. His death appears to have been sudden and almost unexpected. He died on the 11th inst., at the age which is usually considered the prime of life, viz., forty-eight.

Evidence of M. Niaudet's activity and capability is to be seen in the fact that in addition to the duties devolving upon him as a member of the firm of Breguet, he found time to discharge those of manager of the Société Générale des Téléphones, of the Compagnie Electrique, and of the Société d'Eclairage Electrique, as well as those of Chairman of the Compagnie Internationale des Téléphones. He was a member of various scientific societies, amongst others, the Société Francaise de Physique. He was also elected a foreign member of our own Society of Telegraph Engineers and of Electricians on the 8th May, 1872.

He was a frequent contributor to the French scientific press, notably to *La Révue Industrielle*, *L'Electricien*, and *La Nature*. Two of his contributions to these papers were translated for our pages and will be found in Vols. V. and VII.* He also contributed some original communications to the *Journal of the Society of Telegraph Engineers*, which will be found in Vols. VII. and IX. of that journal. He was the author of several works, amongst which were "Applications du diapason a l'horlogerie," published in 1866; "Machines Magneto-Electriques Gramme," published at Paris in 1875, and written in the name of A. Niaudet-Breguet; "Téléphones et Phonographes, étude complete de ces inventions," Paris, 1878; "Traité élémentaire de la Pile Electrique," Paris, 1878, of which an English translation was made by L. M. Fisbach, and published in New York in 1880; and "Machines Electriques à Courants Continus," of which a second edition was published in 1881. His researches on dynamos and batteries entitle him to a high rank among those who have studied in this direction.

He took an active part in the proceedings incident to the Great Electrical Exhibition at Paris in 1881, and the congresses which were held at the same time. We find his name amongst the chancellerie of the International Congress of Electricians, whilst he was also elected president of one of the sections of the Réunion of Electricians held at the same time as the Congress.

During the Franco-Prussian war of 1870-71 M. Niaudet spared neither money nor labour in his country's cause. In 1870 he was shut up in Metz with the Army of the Rhine, and devoted himself to organising its telegraph service. Whilst in this city he devised several means of communication with the outside world, but with what success we do not know. Finally he escaped from Metz, and joined the Army of Defence.

His activity and energy are well known, and his authority on questions of electrical science and practice unquestionable. We may quote here a paragraph from a brief notice of his death that appears in the *Révue Industrielle* of Wednesday last. Our contemporary says:—"Inventors always experienced a kindly reception at his hands; workmen consulted him to their benefit, whilst *savants* themselves appreciated his experience. An inventor of an electric battery, he was one of the first to foresee the part that would be played by machines in the production of electricity; indeed, he had himself designed a small and very ingenious machine for laboratory use."

He was a frequent visitor to this country, and rarely failed to acquaint his countrymen with any new discoveries that came under his notice in the course of his visit, through the columns of one or other of the Paris technical journals devoted to electricity.

The loss that electrical science has sustained in the death of Alfred Niaudet is great, and will be felt far beyond the shores of his own country. His capabilities may be estimated from the work he accomplished during his short life, of which we have here given but a faint outline.

CORRESPONDENCE.

VIENNA CITY RAILWAYS AND ELECTRICITY.

TO THE EDITOR OF THE ELECTRICIAN.

Sir: My attention has been called to a paragraph in a letter from the Vienna correspondent of the *Economist*, in their issue of the 6th inst., which contains statements regarding the project for constructing a system of normal gauge metropolitan railways in this City—for which a concession was granted by the Austrian Government in the early part of this year to Mr. James Clark Bunton and the writer—which are entirely inaccurate.

The project has not failed because the necessary capital could not be raised, nor failed in any way; on the contrary, it has been and is being vigorously prosecuted, and at the moment I am engaged in passing the detailed working drawings of the various sections of the railway through the office of the Railway Department of the Ministry of Commerce, as

* "Noé's Thermo-electric Battery," Vol. V., p. 299, and "The Work Duty of Coupled Dynamos," Vol. VII., p. 186.

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without the proper sanction of the authorities to such documents no works can be commenced.

The promoters of the business in England and elsewhere have wisely decided that, during the present dull time in the money markets of Europe, it is best to postpone the issue of any public company for so large an undertaking, but they continue cheerfully to provide the funds required for the completion of the technical work, involving a very heavy weekly outlay, as is perfectly well known in Vienna. In consequence, the Austrian Government recognise the *bonâ fides* of the undertakers of the railway, and not only grant them sufficient time to complete their drawings, sub-contracts, and financial arrangements, but also continue steadfastly to hold to their decision that the scheme I have had the honour to submit to them, which they adopted after months of scientific investigation from amidst a host of rival projects, is the only one which will fully satisfy the requirements of the City and of the military authorities, the latter being a paramount consideration in Austria, and as such excluding the acceptance of mere "tramways" intended to be worked by electricity, or compressed air in iron tubes buried beneath the streets, in the manner suggested by Messrs. Siemens and Halske and others.

Messrs. Siemens and Halske have *not* obtained a *concession* for any such system of railways in Vienna, as stated by the correspondent of the *Economist*, nor is there in my opinion, nor, in the opinion of any person resident here, the remotest probability of their receiving any such document from the Government. The only concession in existence is that granted on the 25th of January last to Mr. J. C. Bunton and the writer, already referred to.

They have applied for or obtained what is termed a "Vor-concession," which means nothing more than *permission to make studies*, of which hundreds are issued every year in this country to any one sending in a petition for same and paying a few florins for stamps.

It is true, as stated by the correspondent of the *Economist*, "that the same firm (Siemens and Halske) some time ago opened a small line of electric railway to the Electric Exhibition" of a few hundred yards in length, such as they laid down at the former Vienna Exhibition, at the Darmstadt Exhibition, the Crystal Palace, and elsewhere.

These "toy railways" serve the purpose of the moment, and are invariably transported from place to place. They also serve another useful purpose of a very different character.

The real purpose of the notice which the Vienna correspondent has caused to be inserted in the *Economist* is readily understood when read in connection with a paragraph from an article on the same subject in the Vienna *Tagblatt* of this morning, from which I crave space for an extract, printing the words which contain what Americans call the "nub of the thing," in italics.

The *Tagblatt* says: "With regard to the arrangements between the Länderbank" (which, by the way, is a remnant of the institutions founded by the celebrated Mr. Bontoux in this city) "and Messrs. Siemens and Halske, according to the information *imparted to us*, the same has been made for some years. The arrangement is not confined to carrying out the electrical railway in Vienna alone, but *extends to exploiting the inventions and patents of the firm throughout the Empire!*" Electrical companies and firms are not having a good time of it just now, and require a good deal of "*exploiting*," or, in other words, advertising the machines they make to meet competition, and it appears to me that Messrs. Siemens and Halske have hit upon a very good form of advertisement during the period of the Electrical Exhibition and the running of their "electric tramway" in the Prater, when they announce their intention to extend the system on pillars and in tubes through and under the busy streets of Vienna; but when it is stated further, in effect, that this ingenious project is suggested because that of the Vienna City Railways Company has failed, ingenuity is surpassed.—Yours, &c.,

JOSEPH FOGERTY.

Offices of the Vienna City Railways Company,
1, Schwarzenberg Strasse, Vienna.
10th October, 1883.

ON ELECTRIC LAUNCHES.*

BY M. A. RECKENZAUN.

In treating this subject I have taken into consideration the fact that I have the honour of addressing many members of the engineering profession, and that to them one fact is worth any number of speculative theories, hence I have thought well, tempting as the occasion is, to abstain from indulging in prophecies, and confine myself purely to a description of what has been accomplished in practice, and of the results of experiments connected therewith.

Jacobi's and Trouvé's ingenious experiments are well known and appreciated, but the data furnished by these *savans* afford us very little encouragement to pursue the matter in the paths chosen by them, since the said experiments merely demonstrated a philosophical possibility rather than presented the solution of the problem in a practical light.

The idea of utilising primary batteries which depend upon the consumption of zinc for motive power purposes cannot hold good, since we have the means of converting steam and water power into electrical energy through highly efficient dynamo machines, and since we are enabled to reconvert electricity into mechanical power by means of highly efficient motors.

Our first and principal desideratum for the purpose of propelling a boat was a portable and detached medium capable of holding the electric current generated by the dynamo machine; a storage battery of great capacity and comparatively small weight, capable of dealing the accumulated energy out in large or small quantities with very little loss, and these desirable qualities were furnished by the Faure-Sellon-Volckmar accumulator.

Within the last twelve months two launches have been fitted out by the Electrical Power Storage Company at Millwall, the object in view being to demonstrate that sufficient electrical energy can be stored within the hulls to enable them to make a journey of from fifty to sixty miles at a fair rate of speed with one charge. The essential points of difference between the two launches lie mainly in their external dimensions and the means adopted for transmitting the power from the motor to the screw propeller.

The first vessel, named "Electricity," was launched at Millwall in September, 1882. She is 25ft. long, 5ft. beam, and draws 21in. forward and 30in. aft, with ten passengers on board.

Forty-five accumulators stored under the seats and decks forward and aft supplied the current to two D 3 Siemens series dynamos, placed side by side on the floor of the boat, with their axes parallel to the propeller shaft.

To construct a screw propeller to run well at nearly 1,000 revolutions per minute was then considered a new departure, involving elaborate experiments, therefore it was resolved to employ some intermediate gearing, suitable for the occasion, giving the screw 350 revolutions, whilst the motors ran at 950 revolutions.

A Collis Browne two-bladed propeller of 20in. diameter and 3ft. pitch was employed in these first experiments. In the screw shaft was keyed a pulley driven by a strap from a smaller pulley on an overhead countershaft; on the same countershaft two other pulleys, one of which was provided with a friction clutch, received their motion from the two dynamos or motors on the floor. This boat, with the gearing, was illustrated in *Engineering* and in *The Electrical Review* soon after the first trip; it is therefore unnecessary to go into any minute description of mechanical details, and the electrical arrangements may be found more interesting.

The two motors were coupled in parallel circuit, whereas the cells were arranged in series. Each machine had its own switch and ammeter; and the starboard machine could be stopped mechanically by means of a friction clutch.

No better (dynamo) motors could be found for equal power, weight, and space than the Siemens horizontal machines. Previous to placing them into the boat, these machines were subjected to a series of tests with the Prony

* Paper read before the Mechanical Section, British Association Meeting, September, 1883.

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brake at various speeds and powers to ascertain the most convenient conditions for working, and a few of the results will be found in the following table referring to one of two identical machines:—

TABLE I.

D 3 Siemens Motor. Rev. ·77 Ohm.

E.M.F. Battery.	E.M.F. Motor.	Revs. p.m.	Current amperes.	Brake H.P.
70·44	63·33	704	21·47	1·40
„	61·10	528	28·44	1·65
„	69·46	1008	13·82	1·00
100	84·30	950	21·0	1·86
„	82·12	694	33·25	2·78
106	86·04	780	33·68	3·12
„	89·68	1124	21·01	2·56
116·5	94·07	906	27·97	2·83
„	96·27	1226	21·35	2·45

One of the trial runs from the wharf of the company's works at Millwall to the Old Swan Pier, London Bridge, took 23 minutes, returning to Millwall in 30 minutes, the tide being in favour of the up journey. On this trip we carried 47 cells and four passengers.

The two motors running simultaneously absorbed a current of 46 amperes, while the propeller shaft revolved at 360 revolutions per minute. When disconnecting one of the motors the current passing through the other was 33 amperes, and the speed of the screw shaft fell to 250 revolutions.

The single motor must have developed about 2·75 horse-power on the shaft, whereas the two motors combined, with a current of 23 amperes each, gave about 3·75 horse-power according to the nearest test in the above table.

The single motor had to work up to its maximum capacity, which is 2·78 horse-power, with an E.M.F. of 100 volts, and the reduced speed of the screw corresponds to the increase of current. These results demonstrate the fact that, with a given E.M.F., the current is proportional to the load, so long as the motor is capable of absorbing larger currents without loss of efficiency.

The following table (II.) gives the results of tests made with this same motor when running without any external work; it shows how much energy is absorbed by the machine itself. The speed of the armature varies directly with the E.M.F., whilst the current remains practically constant. The weight of the armature, and friction may in this case represent a constant load.

In all these tests the angle of the collecting brushes was the same, as the reversing lever did not permit of any adjustment.

It would be erroneous to take these figures as the equivalent of the losses going on in this electro-motor when doing external work, because then certain conditions will be altered. As the current increases with the load, so the work of energy due to heating of the wires increases; the friction in the bearings, moreover, will be greater in proportion to the extra pressure upon the armature spindle.

TABLE II.

D 3 Siemens running without load.

E.M.F.	Current.	Revs.	$\frac{E \times C}{706}$.
9·24	2·3	400	·028
11·88	2·3	538	·036
13·20	2·4	580	·042
15·18	2·5	700	·050
17·16	2·6	784	·059
18·48	2·6	862	·064
23·76	2·8	940	·089
27·06	2·9	1180	·105
29·04	2·9	1232	·112
33·00	2·9	1389	·128
34·32	2·9	1589	·133

At 1,226 revolutions, with 116·5 volts and 21·35 amperes this motor gave 2·65 horse-power on the brake; this shows a commercial efficiency of 73·3 per cent., and the efficiency calculated from the E.M.F. taken at the terminals of the machine when running is as high as 89 per cent. According to the recent experiment, without a load, at 1,232 revolutions, only ·112 horse-power was absorbed, or 4·73 per cent. of the brake horse-power, at nearly the same speed; therefore this mode of comparison cannot be applied.

When high speeds can be employed it is more economical to use a high E.M.F. with comparatively small currents, but in cases where the speed has to be reduced by gearing, the advantages of small currents may be more than counterbalanced by the disadvantage of mechanical friction.

Marine engineers, who are accustomed to experimenting with screw propellers, will find the electro-motor and secondary battery the most convenient form of motive power in research work. With three simple instruments, the ammeter, voltmeter, and speed counter, every condition can be determined in an instant, and with the greatest precision.

Thus far we have dealt with the results of the launch "Electricity" as originally designed, and it remains only to be mentioned that the D 3 Siemens machine stands 10in. high, its length over all is 28in., and its width 23in. Each machine weighs 316lb., the countershaft supports and pulleys 180lb.

Each cell weighs 56lb., and is capable of furnishing 350 ampere hours, or a fairly constant current for 7½ hours, at the rate required by this boat.

A cell is made up of 40 plates of lead, each 7½in. long by 5¼in. wide, placed vertically into an ebonite box. These plates are separated from each other by narrow india-rubber strips, and the box is filled with dilute sulphuric acid. Each plate weighing 15oz. is capable of holding 8·75 ampere hours, and the whole box with 40 plates represents an energy of 1,858,000 foot-pounds, allowing two volts per cell.

One pound weight of battery power, including the lead, acid, receptacle, and fittings will yield 33,000 foot-pounds, or one horse-power per minute. Having succeeded in our primary object, viz., to prove that we could store and carry in accumulators sufficient energy to propel a boat; it became a question of reducing the weight and space of the machinery by abandoning the speed-reducing gear altogether.

To this end the two motors were replaced by a single D 2 Siemens machine fitted with reversing gear, and weighing altogether 658lbs., whereas the former arrangement weighed 812lb.

This machine is very powerful, as will be seen by the accompanying Table III. of tests. We only required four horse-power with a maximum of 50 cells in series. In this case the dynamo spindle was coupled direct to the screw shaft, which arrangement allowed of increased room for passengers by reason of the absence of the countershaft and belts, so that the whole space occupied by the motor was only 30in. in length, 28in. in width, and 15in. above the floor, the box which covered the machine forming a seat for passengers.

A special propeller had to be constructed for this purpose on the same lines as the original screw, but with a finer pitch, and the following experiments were made with a view of ascertaining the most economical dimensions of blades for high velocities. The object of reducing the blades was to obtain a higher speed of shaft with the same E.M.F. and less current:—

TABLE III.

D 2 Siemens motor. Resistance, ·36 ohm.

E.M.F. Battery.	E.M.F. Motor.	Revs. per. min.	Current amperes.	Brake h.-p.
78·4	68·6	540	42·9	2·7
„	69·8	754	34	2·3
95·5	85·7	720	42·9	3·6
„	88	870	37·1	3·5
„	88·5	1150	29·7	2·9
117·6	105·4	880	44·5	4·4
„	107·8	1200	37·1	4·8
137·2	122·5	1130	47·8	6·8
139·6	125·0	1200	42·9	6·0

First Experiment.

Diameter of screw, 19¾in.; mean pitch, 12·9in.; expanded blade area, 103 square inches. With 45 cells in circuit the

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motor took a current of 57·2 amperes, whilst the screw made 6·30 revolutions.

Second Experiment.

Diameter of screw, $18\frac{3}{4}$in.; mean pitch, $12\frac{1}{4}$in.; expanded blade area, 82; the same cells, 46 amperes at 748 revolutions.

Third Experiment.

Diameter of screw reduced to $17\frac{3}{4}$in., the pitch $11\frac{1}{2}$in., and the expanded blade area to 66 square inches. With 46 cells in circuit the motor consumed only 43 amperes, and the propeller speed rose to 840 revolutions per minute.

As the blades were reduced by merely chipping and filing, they assumed a rather irregular shape, and the speed of the boat itself did not rise as fast as the number of revolutions would warrant.

But since writing the above I have succeeded in obtaining excellent results with a new screw propeller, the one you see before you on this table, and which was designed by Messrs. Yarrow.

With this screw the speed of the boat was actually as great as the rate calculated from the pitch; there was no slip. The dimensions of this propeller (two blades and of forged steel) are of $18\frac{1}{2}$in. diameter, 11in. pitch, and 90 square inches expanded blade area; number of revolutions, 813; current, 46 amperes, with 46 cells.

This experiment having been performed so very recently I have not had an opportunity to investigate the phenomena; but it may be reasonable to assume that the finer the pitch of a propeller, and the greater its velocity under water, the nearer we approach the conditions of a screw passing through a solid substance.

The second launch of which I spoke was made by Messrs. Yarrow and Co., of Poplar, in conjunction with the Electrical Power Storage Company, and this craft is now at the Vienna Exhibition. She is 40 feet long, with 6 feet beam, and can carry 40 passengers quite easily, for the whole of the machinery and secondary cells are conveniently disposed under the floor as ballast.

The motor in this case is a D 2 Siemens dynamo, which develops nearly seven horse-power with 80 cells and a current of about 40 amperes. No gearing is used, and the spindle of the motor is coupled directly upon the propeller shaft.

The screw is two-bladed, of thin forged steel, and was designed by Messrs. Yarrow. Its diameter is 19 inches, pitch 13 inches, making 750 revolutions per minute, with 60 cells, and 41·22 amperes of current at a speed of 8 miles per hour.

Forty amperes is a very convenient rate of discharge for these small cells, but when great power is required for a short time they can yield 60 to 80 amperes, and the same weight of accumulators can furnish double the power, but for less than half the time. In this manner very high speeds may be obtained with but a moderate weight, and this is a most important desideratum in the propulsion of small vessels. With a weight of 126lb, representing 21 small cells, a current of 20 amperes through 42 volts has been attained for one hour, leaving a considerable charge available at a lower rate, and in cases where an intermittent discharge is convenient, still higher rates of current are admissible, since the cells recover themselves after short intervals of rest.

The fact that the propeller may be coupled directly to the armature spindle of the motor has rendered this method of electrical propulsion peculiarly adaptable to many cases where, as an auxiliary or primary power, steam is not available, because the boiler, stokehole, and engines must necessarily take up the best part of the vessel; but with this method, since all the machinery and cells are bestowed under the floor, and not necessarily all together, the boat may be trimmed to any desired line of flotation, and the weight being constant the draught will remain so, while the room for cargo or passengers is practically that of a sailing boat. The scores of small steam launches for harbour master, police, &c., may be advantageously replaced by electric boats.

The work done by the propeller in the water will in any case be at least one half of the work expended by the steam engine or water or other power near the shore used for charging the cells, so, from an economical point of view, an electrically-propelled launch will not cost more than a steam launch, since the consumption of fuel in launch engines is considerable. A steam boat will carry no farther than an electric boat, because coal can be had anywhere. The distances for electric launches will be limited until stations are established, when the cells can be recharged after every fifty or sixty miles' run.

A steam launch requires two attendants, one to attend to the engine and boiler, and the other to the steering. In an electric launch the man who steers can also start, stop, reverse, or regulate the speed, for these operations are all effected by the mere turning of two small handles, as easily as one would turn on or off or lower the gas in a room; in this respect there would be an appreciable saving in wages. There is no fear of an explosion in an electric launch, there is no danger of a serious shock, the internal resistance of 100 cells is only ·5 ohm.

An electric launch 40ft. long will carry as many passengers as a steam launch of 50ft. length; and, finally, there is the total absence of smoke, dirt, smell, noise, and heat—points of great importance in pleasure boats as well as in vessels of warfare.

THE INTERNATIONAL ELECTRICAL EXHIBITION AT VIENNA.

(FROM OUR SPECIAL CORRESPONDENT.)

VII.

The United States Electric Lighting Company, of New York (better known, perhaps, under the title Maxim-Weston), exhibited some of their improved Weston machines, supplying current to arc lamps and to incandescent lamps. The machines used for arc lighting are wound with different-sized wire to those used for incandescent lighting, but the type is the same. One machine, illustrated in Fig. 1,

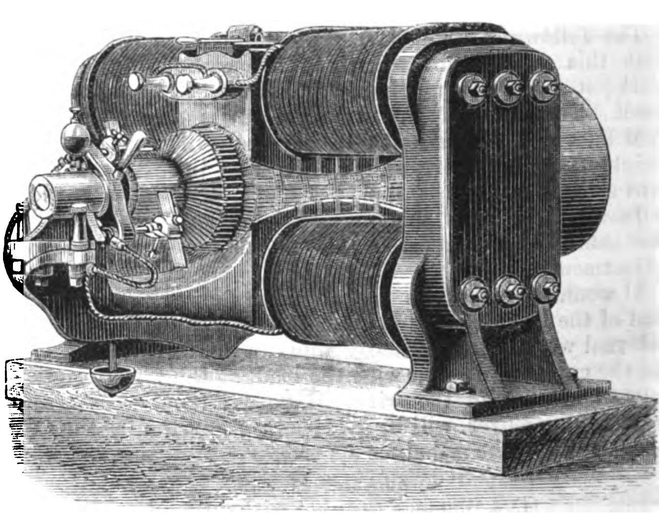

Fig. 1.—Weston Dynamo Machine.

supplies the current for twenty arc lamps in the Rotunda. Two other machines supply current respectively for 104 and 90 Maxim incandescent lamps, in the rooms fitted up to show the adaptability of the light to interior illumination. Two other machines supply current to two projectors in the south portico. The only suggestion to be made about this exhibit is that instead of the normal candle-power being taken between 30 and 40 candles for the Maxim lamp (when, in our opinion, it is too yellow) the higher and far more effective standard of 60 candles should be taken. We have found that Maxim lamps when properly made are better in every way when run at the higher candle-power.

The modifications made in the machine will be seen by comparing the illustration now given with that in our issue of February 25, 1882, when the machine exhibited at the

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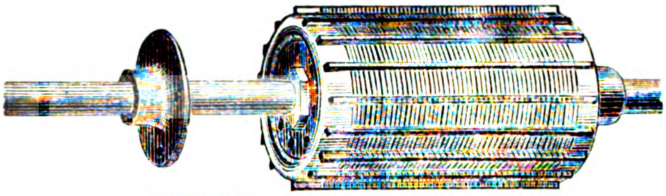
H.-P. applied to Generator.	Revolutions.	Amperes.	Internal Resistance.	Resistance of Arcs.	No. Arcs.	Total Resistance.	H.-P. in circuit.	H.-P. in Arcs.	Candles per Arc.	Candles per H.-P. applied.	Gross Efficiency. H.-P. in Circuit / H.-P. applied.	Net Efficiency. H.-P. in Arcs / H.-P. applied.
6·596	690	18·45	2·11	8·30	7	11·49	5·243	3·786	1548	1642	79·5	57·4
6·8	700	18·61	2·13	8·30	7	11·58	5·372	3·89	1700	1750	79·0	57·2
9·59	920	18·41	2·15	13·51	8	16·80	7·633	6·138	1995	1660	79·6	64·0
9·56	920	17·73	2·13	14·53	9	17·88	7·54	6·138	1710	1610	78·9	64·2
9·48	930	17·65	2·13	14·67	10	18·10	7·557	6·124	1235	1300	79·7	64·6
10·33	935	19·39	2·15	13·70	8	16·99	8·567	6·9	2100	1626	82·9	66·8
9·945	935	18·27	2·15	14·76	9	18·13	8·112	6·594	1796	1625	81·5	66·3
9·781	935	17·93	2·15	15·00	10	18·45	7·958	6·456	1217	1244	81·4	66·0

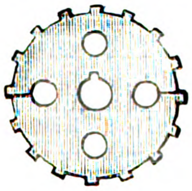
Crystal Palace was described and illustrated. The most recent authoritative experiments with this machine are those given by Lieut. J. B. Murdock, U.S.N., who carried out quite an exhaustive series of tests with a number of machines. We give these results in the above Table, and it will be well to remember them when the report of the exhibition is issued to see how the independent tests corroborate each other, or the contrary.

Figure 2 shows the armature of this machine. It is



ARMATURE CORE AND SINGLE DISC

D



ARMATURE COMPLETE

built up of a series of iron discs, D, upon the axle, the discs being separated slightly from each other. The skeleton is then wound, as shown in the complete armature. The field magnets are placed in a horizontal position upon each side of the armature, and their cores, pole pieces, and yoke plates form a rectangle of cast iron which serves as the frame of the machine. The yoke plates at each end are carried down so as to form feet, which support the machine, and the supports for the armature bearings are cast in one piece with the frame. Altogether this machine is better designed, constructionally, than was the old form. It may be asked, In what particular or particulars does this machine differ from others? We can only reply by asking another question, or other questions. What constitutes a difference, the application of a new principle, or a new application of an old principle, or something else? The something else must be looked for here, for there is nothing new in the construction or disposal of the field magnets, nor, so far as we can see, is there anything new in the construction or disposal of the armature. There-fore the "something else" is simply to be found in the design of the casting. The armature seems to be a modification of Siemens, Edison, and Pacinotti. The core is split up into a large number of separate sections, as in the Edison, the winding is longitudinal, as in the Siemens, and the connections with the commutator are as in Pacinotti, Gramme, &c. The best feature of these well-known machines when combined should give pretty good results, though the results given above are not so good as those obtained from the Gramme, Siemens, or Edison separately.

It is needless to describe the Maxim incandescent lamps, or the Weston arc lamps, and whatever may be our views as to the originality of the machine, there is no doubt that, as a whole, the exhibit must be pronounced as very good. The machines are driven by two of Robey's engines, one 25 horse-power, the other of 16 horse-power, and of the usual type.

Close to this exhibit is that of Crompton and Bürgin, where six machines of a well-known type are exhibited. Three of these machines, those exhibited by Messrs. Crompton and Co., are from Chelmsford, the others are from M. Bürgin's factory in Switzerland. Two of Messrs. Crompton and Co.'s machines generate current for the arc and incandescent lamps lighting the library, the rooms fitted up for telephonic purposes, and that portion of the gallery leading to the library. A compound machine is used for the incandescent lamps, which are of the usual Swan type, while the other machine gives the current required by the arc lamps. The other Bürgin machines were also running to supply current to arc and incandescent lamps. M. Bürgin exhibited also his exploder and his motor. A good deal of amusement was found in connection with the exploder, it being a favourite idea among those in charge to get some one to take a shock. We have described these machines so frequently that we fail to find anything new to say, except that, so far as we know, these "compound" machines have not previously been exhibited, so that to the majority of visitors they are an entirely new feature. Our readers, however, will know that externally they differ very little from the ordinary Bürgin, while the method of compound winding and the theory of such machines has been treated at considerable length in these columns. We shall have to refer to the compound machines again, and the results obtained from them.

ON THE MAGNETIC SUSCEPTIBILITY AND RETENTIVENESS OF SOFT IRON.*

By I. A. Ewing, B.Sc., F.R.S.E., Professor of Engineering in University College, Dundee.

During three years the writer has been engaged while in Japan in prosecuting researches on the magnetisation of iron and steel and on the effects of stress on magnetic susceptibility and thermo-electric quality. Preliminary notices of some

* Paper read at the British Association, Southport Meeting, September, 1883.

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of his earlier results have appeared in the *Proceedings of the Royal Society* (Nos. 214 and 216, 1881, and No. 220, 1882), but a detailed account of the work has still to be given. Meanwhile the following points not previously noticed are perhaps of sufficient interest to warrant their separate publication.

In the experiments on magnetisation iron and steel wires were used, either welded into rings, or in the form of straight pieces whose length was great enough to make the influence of the ends negligable. Curves were obtained, in some cases by the ballistic method, and in some by the direct magneto-metric method, showing the changes of magnetisation which occurred when magnetising force was gradually applied, withdrawn, reapplied, reversed, and so on.

The results of many experiments with several specimens of carefully annealed soft iron wires have shown that they possess in very high degree a property not generally credited in soft iron—the property of remaining strongly magnetic when the magnetising force is removed.

As an example the case may be cited of an annealed iron wire which was subjected to a magnetising force of 22·4 C.-G.-S. units. This gave it a magnetic induction amounting to 16,000 C.-G.-S. units. When the magnetising force was removed (gradually and completely) the induction fell only to 15,000. In other words, the intensity of residual magnetisation was equal to nearly 1,200 C.-G.-S. units.

Here more than 93 per cent. of the whole induced magnetisation survived the removal of the magnetising force, and in many other cases the residual magnetism amounted to nearly 90 per cent. The somewhat extraordinary spectacle was thus presented of a piece of soft iron entirely free from magnetic influence, and nevertheless holding an amount of magnetism far in excess of what is ever held by a permanent magnet of the best tempered steel. In this condition, however, the magnetic character of the iron is highly unstable. The application of reverse magnetising force quickly causes demagnetisation, and the slightest mechanical disturbance has a similar effect. Gentle tapping removes nearly all the residual magnetism. Variations of temperature reduce it greatly, and so does any application of stress. On the other hand, if the iron be carefully protected from disturbance, it seems that the residual magnetism disappears only very slowly, if at all, with the mere lapse of time.

If after magnetisation the magnetising force be suddenly removed, the residual magnetism is (as might be expected) considerably less than when the force is removed gradually. The ratio of residual to total magnetisation is always small when the intensity of magnetisation is small, and passes a maximum when the intensity is increased. The maximum is particularly distinct in wires which have been hardened by stretching, but it occurs also in soft annealed wires. In one instance, where the wire had been hardened by stretching, the maximum ratio of residual to total magnetism was 0·60, which was given by applying and removing a magnetising force of about 10 C.-G.-S. units; but on the application of a force of 90 units the ratio fell to 0·33. With steel the maximum in this ratio is less sharp, but still distinct. Neither in hard iron nor in steel is the ratio, even at its maximum, so great as in soft iron, where (as has been said above) it frequently reaches 0·9. During the first magnetisation of soft iron wires the ratio K of intensity to magnetisation I to magnetising force was generally about 200, sometimes nearly 300, and by gently tapping the wire during the application of magnetising force this co-efficient was on one occasion raised to the enormous value of 1,590. In the case alluded to the magnetisation went on as rapidly as the magnetising force was increased, that a force of 1 C.-G.-S. unit gave an induction of 10,000.

In this and other particulars the experiments have been strongly confirmatory of the idea that there is in soft iron a static frictional resistance to the rotation of the magnetic molecules, which is the principal cause of the remarkable retentiveness described above, and which is overcome by mechanical agitation.

Numerous measurements have been made of the energy expended in taking iron and steel through cyclic changes of magnetisation. For example, in changing the magnetism of one specimen of annealed iron wire from $I = 1,250$ to $I = -1,240$, and back, the amount of work done against magnetic friction (apart from any induction of currents) was 1,670 centimetre-dynes per cubic centimetre of the metal. In hardened iron, and especially in steel, the work done is far greater.

The effects of stress on existing magnetism, and on magnetic susceptibility, have been examined at great length. The most remarkable effects occur in wires which have been hardened by stretching. In these the presence of a moderate longitudinal tensile stress increases the magnetic susceptibility immensely for low values of the magnetising force, but diminishes it for high values. It also increases very greatly the ratio of residual to total magnetisation, but both of those effects pass a maximum when the stress is sufficiently increased.

The whole subject is much complicated by the presence of the peculiar action which, in previous papers, the writer has named Hysteresis, the study of which in reference both to magnetism and to thermo-electric quality has formed a large part of his work.

THE EDISON-HOPKINSON DYNAMO.

It will be remembered that in our issue of August 11th we gave the report of Mr. Sprague on this machine. The Edison Company has just issued a little pamphlet describing the machine, from which the following information is taken:—

The general type of the Edison dynamo as originally made in America is well known. It was a shunt dynamo with long cylindrical field magnets placed vertically on cast-iron pole pieces, between which the armature revolved. The three forms of the machine known as the Z, L, and K machines had two, four, and six field magnets respectively. In each case the diameter of the iron core was the same, being about 6¼in. and overlaid with six layers of No. 17 B.W.G. copper wire, the resistance of each magnet being about 20 ohms, the opposite legs being coupled in series, and the pairs in multiple arc.

The speeds, weights, and lamp-loads of these original machines are given in the annexed table:—

TABLE I.

Dynamo old form.	Safe lamp load.	Speed to obtain 110 volts.	Height over all.	Floor space.	Weight.
Z	60	1200	6′	3′ 8″ × 3′ 3″	3,000lb.
L	150	900	6′ 6″	5′ 3″ × 3′ 3″	6,000lb.
K	250	900	6′ 6″	5′ 10″ × 3′ 3″	8,250lb.

The following are the other electrical data of the machines:—

TABLE II.

Dynamo old form.	Resistance of armatures.	Resistance of fields as coupled.	Current given at normal speed.
Z	·16 ohm	40 ohms.	45 amperes.
L	·10 ohm	20 ohms.	112 amperes.
K	·032 ohm	13·3 ohms.	180 amperes.

Taking the floor spaces occupied as about 12, 17, and 19 square feet respectively, and dividing these areas and the weights and prices by the safe lamp load in 16 candle lamps, we have in the annexed table (III.) data calculated per lamp for each machine.

TABLE III.

Dynamo.	Floor space occupied per Lamp.	Weight per Lamp.	Price per Lamp.
Z	·2 sq. foot.	50lb.	£2 10 0
L	·11 sq. foot.	40lb.	£2 0 0
K	·076 sq. foot.	33lb.	£1 16 0

Now taking these machines as a whole, and accepting the fact that their electrical efficiency was very high, though not, perhaps, as high as possible, it was evident that considerable

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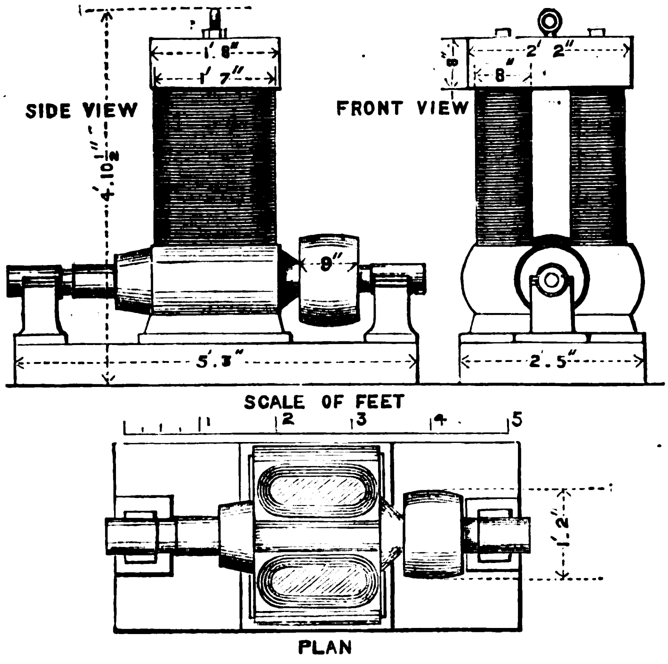
modification in two directions was necessary. 1st. The speed required to obtain the 110 volts was too great, putting direct driving out of the question, for the power required at full load. 2nd. The price per lamp was too much. The necessity for a slow speed dynamo was forced on the attention of the company by the requirements of ship lighting, and about a year ago experiments were carried out at Holborn-viaduct which led to a reduction in the speed of one machine, viz., the L, without affecting its economy. Dr. Hopkinson has subsequently carried out elaborate investigations, which have led to an entire modification of the machines and valuable improvements, resulting in (1) increasing the efficiency, (2) decreasing the speed required to obtain the working electromotive force, (3) decreasing the cost per lamp of the machines or equivalently raising their output, (4) decreasing the weight and standing area per lamp, lamps being always understood to mean 16 actual candle-power lamps.

The change made first in the L machine consisted in increasing the mass of the iron magnets and increasing the convolutions of the fields, without increasing the total field resistance. The iron cores of the L machines were increased one inch in diameter, and two additional layers of wire put on. It was then found that the 100 volts or thereabouts could be obtained at a speed of about 500 revolutions per minute instead of 900, without at the same time increasing the consumption of energy in the field magnets. The total weight of the machine was increased by 6cwt., 4cwt. 3qrs. being extra iron, and 1cwt. 1qr. being extra



Edison-Hopkinson 250-Light Dynamo.

wire. The efficiency of the machine was not altered, but the convenience of lower speed and the possibility of direct driving were obtained by a slight increase in the weight and cost per lamp. A number of these "Altered L" machines were placed on board various steamships *e.g.*, the ss. "Tarawera," "Waihora," "Apolo," "Minerva," "Clan M'Arthur," H.M.S. "Malabar," &c., and performed very satisfactorily when driven by a Brotherhood engine. The improvements of Dr. Hopkinson have gone much further than this, and the advantages of the Edison-Hopkinson dynamo over the old form Edison machine may be stated as follows:—1st. The use of the multiple field magnets is abolished. There is no advantage gained by using several separate field magnet legs rather than one single one. Dr. Hopkinson replaces the multiple magnets by single round, oval or oblong solid field magnets, one in each pole piece and placed vertically or horizontally as the case may be. 2nd. The magnets are, generally speaking, thicker and shorter than in the old machines. This gives the dynamo a more squat appearance and has the great advantage for ship lighting of greater compactness. 3rd. By alterations in the armature the efficiency is increased. The most careful measurements made on a 200 light machine, at Manchester, show an efficiency of 95 per cent.* 4th. The weight and cost of the machines per lamp are greatly reduced.

The data collected on Table IV. give the weights, speeds and principal dimensions of certain machines which have already been constructed on this new type, the first and third machines having round magnets and the second oval ones.

Table IV.

Dynamo.	Weight.	Speed to obtain 110 volts.	Height over all.	Floor space covered.
125 light	3,024lb.	550	4′ 10″	3′ 2″ × 2′ 5″
250 light	5,152lb.	500	4′ 11″	5′ 3″ × 2′ 5″
500 light	11,536lb.	600	7′ 5′	5′ 9″ × 3′ 3″

The floor spaces or standing areas are therefore about 7½, 13, and 18¾ square feet respectively.

Reducing the weights, floor spaces, and costs of these dynamos to the value per lamp we have the following table:—

Table V.

Dynamo.	Floor space per lamp.	Weight per lamp.	Cost per lamp.
125 light	·061 sq. foot.	24lb.	£2 0 0
250 light	·052 sq. foot.	20lb.	£1 14 0
500 light	·037 sq. foot.	23lb.	£1 3 7

If this table be compared with Table III. it will be seen that the new slow speed Edison-Hopkinson dynamos are cheaper and in every way more efficient than the old high speed Edison machines. If, however, we are not restricted to a slow speed the Edison-Hopkinson dynamos can be made to run at much higher speeds, and the cost per lamp is then diminished precisely in proportion to the increase of speed. The efficiency of conversion is also increased. For example, the slow-speed 125 light machine, if run at 1,100 revolutions per minute, maintains 250 lights, requiring, therefore, a floor space of ·03 square foot per lamp only. The illustrations show the dimensions of the new slow-speed 250 light machine.

THE TRANSMISSION OF POWER.*

M. DEPREZ'S GRENOBLE EXPERIMENTS.

The present note relates to the electrical measurements, and to the experiments relating to the distribution of energy. During the whole of the experiments, two Deprez galvanometers were located in the circuit, one at Grenoble, the other at Vizille, and these two instruments constantly indicated that the difference between the current at the two ends of the line was by no means great. Unhappily these instruments did not allow of great precision in the readings, so that, to exactly determine the value of the losses in the line, recourse was had to the chemical method.

Two voltameters formed of plates of pure silver immersed in a solution of nitrate of silver were placed at the ends of the line. These plates had a surface of about one square decimeter; the current was supplied by the generating machine at Vizille. At Grenoble the circuit was closed by an inert resistance. As it was also designed during these experiments to test the galvanometers, these latter were placed by the side of each voltameter. Two trials were made with different speeds of the machine, and the following results were obtained, *vide* Table I.

To determine the value of E, it was admitted that the electromotive force was proportional to the speed N, provided the current did not vary, a fact which was verified with the same machines during the experiments made in the Northern Railway workshops.† A series of a dozen experiments with varying resistances in the circuit of the generator enabled a curve to be constructed having as abscissæ the values of C, and as ordinates the corresponding values of $\frac{E}{N}$. By the aid of this curve the E.M.F. could readily be deduced from the speed of the armature for all the other experiments.

It results from Table I that, during the first experiment, the loss of current was 5·1 per cent. In the second experiment, when the difference of potential at the terminals was about 3,000 volts, the loss was 6·6 per cent.

The other electrical measurements were obtained during some 40 experiments, and enabled the values $\frac{EC}{75g}$ and $\frac{ec}{75g}$ of the electrical works,‡ as well as the electrical return $\frac{e}{E}$ to be cal-

* The full report of these tests will be found in *The Electrician*, of 11th August.

* Note communicated to the Paris Academy of Sciences by M. Boulanger. *Vide The Electrician*, pp. 475 *et seq. ante.*

† *Vide The Electrician*, Vol. X., pp. 449, 477, and 499.

‡ The electromotive force *e* of the receiver was deduced from E by the relation $e = E - A\,C$, A being the total resistance of the machines and line $R + r + e$.

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TABLE I.—RESULTS OF EXPERIMENTS WITH VOLTAMETERS IN CIRCUIT.

No. of the experiment.	Situation of voltameter.	Weight of the positive electrode.		Difference between the weights p.	Duration of the experiment in seconds t.	Current $\frac{p}{\cdot 0011248 \times t} = C$.	Electromotive force of the machine E.	Difference of potential at the terminals E—R C=U.	Remarks.
		Before the experiment.	After the experiment.						
		gr.	gr.	gr.		amperes.	volts.	volts.	
1	Vizille	39·43959	26·20184	13·23775	3500	3·268	2808	2627	The figures ·0011248, taken as the weight of silver deposited per ampere per second, were given by M. Mascart.
	Grenoble	39 78262	27·22920	12·55342		3·099			
2	Vizille	36·03719	27·32190	8·71529	2205	3·514	3128	2934	
	Grenoble	34·68220	26·54200	8·14020		3·282			

TABLE II.—RESULTS OF EXPERIMENTS ON THE DISTRIBUTION OF ENERGY.

No. of the Experiment.	No. of revs. per min. of generator.	Difference of Potential		Receiver No. 1.		Receiver No. 2.		Receiver No. 3.		Receiver No. 4.		Receiver No. 5.		Total work.	Total current.	Remarks.
		At the terminals of the generator.	At the end of the line.	Work per second.	Current.	Work per second.	Current.	Work per second.	Current.	Work per second.	Current.	Work per second.	Current.			
		volts.	volts.	kgm.	amp.	kgm.	amp.	kgm.	amp.	kgm.	amp.	kgm.	amp.	kgm.	amp.	
1	2230	39·4	39·1	18·0	9·7	—	—	—	—	—	—	—	—	18·0	9·7	Weight on each brake 2 kilograms = 4·4lb.
2	2270	39 0	38·8	18·9	9·9	19·6	11·3	—	—	—	—	—	—	38·5	21·2	
3	2238	39·3	39 1	18·6	9·9	19·5	11·3	42·5	18·3	—	—	—	—	80·6	39·5	
4	2238	39·0	38·8	17·6	9·9	19·1	11·5	40·0	17·5	39 5	19 0	—	—	116·2	57·9	
5	2169	39·1	39·1	18·5	9·5	18·7	10·6	40·0	17·2	34·7	18·5	35·3	19·3	147·2	75·2	

culated by making use of the average current. The result of these calculations shows that the electrical differed but little from the mechanical return. In fact the average of the relation between these two returns was found to be ·82. Further comparison between the electrical and mechanical works show that the co-efficient of transformation of the generator is very nearly unity, so that the deficit is caused almost entirely by the receiver.

The second portion of these experiments related to distribution. The receiving machines made use of consisted of three Siemens and two Gramme machines, workshop type. All these machines being wound with thick wire, it was necessary to employ a generator similarly wound. This was a Gramme machine, the magnets of which had been strengthened and double-wound on the Marcel Deprez system. A constant current was supplied by a second machine, used as an exciter, and the two machines were driven by means of a portable engine, which kept the generator at the proper speed for maintaining a constant difference of potential at its terminals. Two parallel wires were led from the terminals of the generator, from which branched off the circuits of the other machines. The difference of potential at the terminals was measured by a resistance galvanometer placed in a shunt circuit. A second similar galvanometer permitted the measurement of the difference of potential at the end of the line. Lastly, the current was measured by a thick wire galvanometer, whose resistance might be neglected.

Each machine, moreover, was furnished with a Carpentier brake, carrying a constant weight of 2kg. The pulleys of the brakes having a circumference of 1m., the work per second was given in kilogrammeters by the expression $\frac{2n}{60} = \frac{n}{30}$, n being the number of revolutions per minute.

Measurements were taken by throwing the machines in gear one after the other. In this way a series of five experiments was obtained, the results of which are given in Table II.

We see from this table that for any one machine the work done and the current did not vary in any notable manner; the machines were therefore independent of one another, and distribution of energy was actually accomplished.

NUMBERS OF "THE ELECTRICIAN" OUT OF PRINT.—The following numbers of *The Electrician* are out of print, and cannot be supplied at the office, viz.:—Vol. 1, Nos. 3, 9, 19; Vol. 7, Nos. 8, 10, 12 to 18, 20, 21, 24 to 26; Vol. 8, 1, 3, 6 to 12, 15 to 26; Vol. 9, Nos. 2, 4, 24, 25; Vol. 10, No. 13.

ON PATENTS FOR INCANDESCENT LAMPS.

BY C. A. STEPHENSON.

(CONTINUED FROM PAGE 525.)

Baking in Powdered Carbon.

Another process of preparing carbon filaments is by baking them in some powdered carbon; Mr. Swan is the first to claim this process. In his patent, No. 250, of 1880, he claims the process of forming carbons, "by subjecting them to heat in a vessel containing charcoal, or other form of carbon in powder."

Apart from any system of carbonising, the use of acids for purifying carbon had long been known; but the use of the acids for purifying a material before carbonising has the appearance of a novelty—I say the appearance advisedly, and I will proceed to show why it is I am unable to give a decided opinion on this matter.

In Mr. Edison's patent, No. 4576, of 1879, he states, without claiming, that he has used paper amongst other substances. Now, in the manufacture of some papers acids are used, although their use is in no way suggested by Mr. Edison. Now, Mr. Swan in his patent, 250, of 1880, claims:—"Forming the carbons for incandescent electric lamps by carbonising vegetable parchment of the required form in the manner described." The vegetable parchment, prior to carbonising, was prepared with sulphuric acid.

In the same year Mr. Swan took out two further patents, Nos. 4933 and 5014. In both he claims:—"Forming the carbon or carbons from cotton thread, converted by the action of sulphuric acid, and carbonised."

I have endeavoured to show the pros and the cons of the case in as few words as possible, but should this question ever be exhaustively discussed I foresee that very much will have to be said on both sides.

Flashing.

By flashing is meant the method of making carbons homogenous, by placing them in a carbon atmosphere, and then heating them by means of an electric current or otherwise. This process, though rejected by Mr. Edison, is much in vogue amongst manufacturers of incandescent lamps. I shall only now deal with the broad principle of flashing, leaving out the many minor details by which the process is now perfected. In Mr. Sawyer's patent, No. 4847, dated 1878, the whole process is fully described and claimed. I will give his own words:—

"It has been found that a pencil of carbon immersed in a hydro-carbon gas or liquid, and heated to an extremely high temperature by the voltaic current, is not itself attacked, but decomposes the surrounding matter, the carbon of which enters

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and fills up its pores to an extent impossible except with matter in a very attenuated state, and deposits a perfectly homogenous layer, generally of a bright grey colour upon the exterior surface. As the carbon increases in size more current is required to maintain its temperature, and if the current is gradually increased in accordance with the demand, for there is apparently no limit to the increase in mass of the homogenous exterior deposit, carbon pencils may be cut from this deposit, or the original pencil with its coating may be used in the lamps.

"In this process it will be seen that the carbon is never in contact with the liquid in which it is immersed, but surrounded by a carbonic gas of very high temperature—beeswax, balsam, and most oils, if pure, operate satisfactorily; almost any hydrocarbon in fact will answer. This invention is not confined to the treatment of carbon alone, since it is obvious that many infusible substances non-conductors of electricity may be treated in hydrocarbon liquids or gases so as to render them conductors of electricity, as for instance a tube of lime enclosing a pencil of carbon through which the electric current is caused to circulate. . . .

"In concluding this description the fact must be pointed out that the consolidated homogeneous carbon of this invention may be produced by the electro-platina process, as well as by the electrical heating of a conductor in a carbon gas or liquid. The cathode, composed either of solid carbon or of an infusible refractory substance coated with plumbago or graphite, is immersed in a carbon liquid, and connected with one pole of the battery. The other pole of the battery is connected with the anode, composed of solid carbon, also immersed in liquid. The passage of the current decomposes the liquid, and deposits a homogenous layer of carbon upon the cathoide."

The claims are :—

"The herein-described method of preparing the illuminating part of an electric lamp, consisting of electrically-heating the same while it is surrounded by a carbon gas or liquid.

"A material for the manufacture of the illuminating conductors of electric lamps produced by electrically heating carbon in carbon gas.

"The illuminating part of an electric lamp, consisting of carbon deposited by electric action.

"A material for the manufacture of the illuminating conductors of electric lamps produced by electric action."

After such an exhaustive description it would be useless to mention other patents claiming the process of flashing; but it is not only for flashing that this process of carbonising has been brought into play; it is also used for joining wires and filaments together, for enlarging certain parts of filaments, and for building up defective portions of filaments.

Joining Wire to Filament.

Various modes of joining wires and filaments have been tried; the original idea of holding the filament in metal clips has been entirely superseded by more modern inventions.

A very good joint is described by Mr. Edison in his patent, No. 4576, of 1879. A compound of plastic lampblack and tar is moulded around the joint, and then carbonised.

The claim is for the method "of securing the platina contact wires to the carbon filament, and carbonising the whole in a carbon chamber."

Mr. Dew, in Patent 2037, of 1880, describes and claims two processes, "embedding the wire in the material previous to carbonisation, and also folding the carbon ribbon on the wire, whereby the metallic conductors are embedded in the material."

In Patent 3765, of 1880, Mr. Edison further improved on his original joint by adding a clamp either of carbon or carbonisable material. His claims are "a carbon clamp for uniting the incandescing and metallic conductors formed of a carbonisable material." "The method of uniting the incandescing and metallic conductors, which consists in inserting both in clamps made of carbonisable material, and then carbonising the whole together."

Mr. Swan's process, described in his Patent 5014, of 1880, does not differ in any very remarkable degree from Mr. Edison's. His claim is for "binding the ends of the cotton thread to the conducting wires . . . and submitting the same to the converting and carbonising process."

Purifying Filaments.

In the manufacture of lamps, after the air has been exhausted, a current is passed through the filament, raising it to incandescence. The filament will now give off certain gases, and in order to expel all such impurities the process of exhaustion is kept up for some time. This process is in very general use, but yet it has been patented, and the patent still holds good.

Exhausting.

In Mr. Sawyer's patent, No. 4847, of 1878, which is for a lamp burning in a "carbon preservative atmosphere," he describes a process of charging the globe with pure nitrogen, and whilst the pure nitrogen is still flowing through the globe, the carbon is heated to incandescence, to drive out all impurities and occluded gases which are carried out of the lamp by the current of nitrogen. His claim for this process is—"when the globe has been charged with a carbon preservative atmosphere before the flow of such preservative atmosphere through the lamp has ceased, and before the lamp is finally sealed, heating the illuminating part by means of an electric current in order to expel impurities and occlude gases."

But for the fact that Mr. Sawyer's lamp is filled with "a carbon preserving atmosphere," instead of being in vacuum, the process he describes of ridding carbons of gases is exactly what is now largely carried on; as it is Mr. Edison was the first to patent this process in vacuum.

In his Patent 2402, of 1879, he claims a method of "preparing metals and metallic conductors for electrical lamps or burners, consisting in freeing the metallic conductors of gases in a vacuum, and then hermetically sealing. . . . Carbon sticks may also be freed from air in the same manner."

Sealing.

There remains now but one process, namely, the method of sealing the wire conductors into the globe. I have already several times noticed Mr. Sawyer's patent, 4847, of 1878. The process for sealing in he therein describes is most elaborate and complicated, and is made up of some half dozen pieces of glass, wood, brass, &c. It has since been found that an efficient seal can be easily and simply made, and that no elaboration is necessary.

In Mr. Lane-Fox's provisional specification, No. 1122 of 1879 (now void) he describes a very simple process of "a globe or other form of glass, through one portion of which the conducting wires are hermetically carried."

Mr. Fox, however, abandoned this simple process, though he has now, in the latest form of his lamps, reverted to it, the conducting wires being simply clamped into the flattened end of the tube supporting the glass bulb. As this simple process appears now to be successful, and as the patent for it is void, it will be useless to follow the many complicated methods that have been from time to time elaborated.

I have now come to the end of the ordinary processes of lamp manufacturing, and I have brought the patents down to the end of the year 1880. All the processes I have described have been patented several times over, for as a rule inventors are ignorant of what has been invented previously, and no minute supervision is exercised. I will give one case in illustration, that of mercury seals for lamps.

In Patent No. 925 of 1880, Mr. Guest claims "a mercurial seal around each conductor and within a closed cup.

Mr. Dew, in Patent No. 2037, of the same year, describes, "bulbs containing mercury for sealing."

Surely it would require but scant supervision to prevent such glaring repetitions within a few months of each other.

1881—1882.

Although a great many patents were taken out during these two years, yet there is not much novelty to be found in the specifications. The main principles of the existing incandescent lamps had been invented prior to the period under review, so that the patents are for the most parts improvements and elaborations of processes already known.

Baking Filaments.

In patent No. 225, of 1881, Mr. Lane-Fox claims the use of a block on which the filaments are bound previous to being carbonised; when bound, the filaments are baked in a crucible containing powdered graphite. The use of a block is a distinct novelty, but the rest of the process was previously claimed by Mr. Swan, in his patent No. 250, of 1880.

A great deal of attention was given to improvements in the preparations of filaments. Mr. Alex. Muirhead, in Patent 153, of 1881, describes a process of preparing the filaments previous to carbonising by soaking them in starch solution, &c., to fill up the pores with carbonaceous matter; the filaments are then embedded in a porcelain tube containing powdered charcoal. So far there is no novelty. A vapour of carbon bisulphide, or wood spirit, is then passed into the porcelain tube, driving out the air; the tube is then closed, and gradually heated to redness.

Mr. Crookes, in Patent 2,612 of 1881, claims a method of "carbonising cellulous that has been dissolved or acted upon by a solution of cuprammonia," and Mr. FitzGerald, in 3890 of 1881, claims the use of a concentrated solution of zinc chloride in the manufacture of carbons.

Flashing.

Various methods of flashing have been patented, all, however,

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modifications or improvements on Sawyer's original patent, No. 4847 of 1878. I shall briefly describe a few of these, but as I am dealing with original patents I must remind my readers that even an improvement is an infringement of a patent.

Mr. Edison, in Patent 5?2 of 1881, proposes forming carbons in moulds suspended in a vapour of volatile carbon, such as bisulphide, or chloride of carbon, volatile paraffin, naphtha, &c. The carbons are formed on metal strips, and the metal is afterwards eaten away with acid, leaving only the deposited carbon. Mr. Jameson, in Patent 4180 of 1880, further improves the process by moulding, and claims "the formation of carbon filaments wholly of deposited carbon."

Thus the process of flashing has grown up till at last the strip on which the flashing took place has totally disappeared.

Joining.

Hitherto in joining the carbon filaments to the conducting wires the joint was formed of a piece of carbon, and various processes of effecting such joints have been patented, but Mr. Edison in Patent 768 of 1881 describes a process of joining by electroplating. In the terms of a disclaimer, dated July 12, 1882, he confined his claim to "the method of uniting the carbon filament and conducting wires thereto in an electric lamp, consisting of first uniting them mechanically in any ordinary manner, and then securing the union by electro plating."

This constitutes a most important improvement. Prior to this the current passed from a metal conductor, through a carbon joint, before reaching the filament, and again through a second carbon joint to the negative conductor. These carbon joints presented an appreciable resistance, and being generally heated only to a dull red, gave no proportional return of light. Another fault was that by adding a considerable but uncertain amount of resistance they increased the difficulty of manufacturing lamps of equal resistances. The bare idea of a metal conductor in direct contact with the filaments has nothing new in it, for in the old and obsolete forms of lamps this was achieved by means of metal holders or clips. These joints, however, not being found satisfactory, gave way to carbon holders, which again have given way to metallic joints either electro-plated or fused on to the filaments.

Purifying Filaments.

Amongst manufacturers of incandescent lamps there is now a general tendency towards simplification and cheapness. In globes and sealing in perfect simplicity has been attained, but in the preparation of filaments there is yet scope for the inventor. The process of purifying filaments by continuing to exhaust the globes whilst the filaments are hot adds very considerably to the expense of manufacturing. Attempts have been made to quicken the process by dipping the filaments in some gas or liquid which would drive out all impurities and would itself readily volatilise under heat, but I believe that up to the present no satisfactory result has been obtained.

(TO BE CONTINUED.)

BRITISH ASSOCIATION.

Address of the President of the Mathematical and Physical Section.*

BY PROFESSOR OLAUS HENRICI, PH.D., F.R.S.

On reading through the addresses delivered by my predecessors in this office, I was struck by the fact that in nearly every case the speaker began with a lamentation over his unfitness for the work before him, and those seemed to me to be the more eloquent on these points who showed by their address that they least needed an excuse. The amount of excuse given appears in fact to be directly proportional to the gifts of the speaker, and hence inversely proportional to the need of such an excuse.

Under these circumstances I cannot express my sense of my own unfitness for this post better than by saying nothing about it. I must, however, beg your indulgence for my shortcomings, both as regards my address and my manner of conducting the general business of this section.

As the presidential chair is occupied by one of the most illustrious of mathematicians, it would be presumptuous for me to give an account of the recent progress of mathematics. I propose only to speak for a short time on that part of mathematics which has always been most attractive to myself—that is, pure geometry as apart from algebra, but I shall confine myself to some considerations relating to the teaching of geometry in this country. Pure geometry seems to me to be of the greatest educational value, and almost indispensable in many applications; but it has scarcely ever been introduced at Cambridge, the centre of mathematics and mathematical education in England.

The number of geometrical methods now in use is astonishingly great. These differ, on the one hand, according to the nature of the result aimed at, but, on the other, according to the amount of algebra employed, and to the relation in which this algebra stands to the pure "*Anschauung*." I use the word *Anschauung* because I know of no English equivalent; the German word has the philosophic meaning rendered by intuition, and retains its original concrete meaning of looking at a thing, and might perhaps be translated: intuition by inspection. It is the inspection of figures which is of the greatest importance in geometry. It is hereby of little consequence whether the figures are seen by the physical eye or only mentally: because the conception of that space in which we perceive everything and without which we can perceive nothing, which therefore is, according to Kant, a form of our *Anschauung*, is built up in our mind through many generations in conformity with sensual impressions.

It would be of interest, if time permitted, to follow up the gradual development and extension of geometry into the wider science of algebra, from the first introduction of the latter in the theory of proportion to the present state, where there exists really no essential difference between the two, where geometry is only one manifestation of algebra, but so complete a one that at least within its number of dimensions it again contains algebra.

In some of the methods just referred to no algebra is used at all, whilst others may be distinguished according to the nature of the algebra used, whether equations containing one, two, three, or more variables are employed. In such a division, Von Staudt's system, without a vestige of algebra, would occupy the one end, and the purely algebraical theory of invariants with geometrical interpretation the other.

There is, however, not only a difference in the amount of algebra used, but, if possible, a greater one in the manner in which the symbols are interpreted. And it is here that algebra has apparently the greater power. One algebraical theorem, by being read in different ways, by giving ever different meanings to the symbols, reveals a variety of geometrical and other theorems. We have in it the crystallised form, the very essence of the mathematical truth, but in the most abstract form conceivable. Now, this most abstract form is the highest and the most perfect which mathematical truth as such can assume, and which it must assume before a theory is really complete in the eyes of a pure mathematician. It is only in this shape that it is ready to be turned to account in any direction where it may be needed.

In thus placing algebra on the highest pinnacle, the reasons will be apparent which will make many mathematicians, not to mention others, prefer the truths it reveals cast in a mould which connects them with concrete things rather than with abstract notions. In fact, to be thoroughly at home in the highest theories of pure algebra requires some of the genius of men like Cayley and Sylvester, who have founded, and to a great extent built up, modern algebra. But even they constantly make use of geometry to assist them in their investigations, and no one could have expressed this more strongly than Prof. Sylvester himself in his brilliant address delivered from this chair at the Exeter meeting of our association.

The one English mathematician whose mathematical thought is purely geometrical is Dr. Hirst, a pupil of Steiner, who in the position which he has just relinquished has been able to introduce, as the first, modern geometrical methods into a regular system of professional education, whilst showing at the same time by his original work what can be done with these methods.

Other mathematicians who have studied these methods—and I believe there are many—have made use of them by translating the geometrical into algebraical reasoning.

Towards the early possibility of such a translation much was done by the labours of the late Mr. Spottiswoode, who years ago wrote the first connected treatise on the theory of determinants, and who up to the last few years employed some of his leisure hours in working out geometrical problems, the work consisting always of some beautiful piece of algebra.

It is not often that our section has to mourn in one year the loss of two such men as Smith and Spottiswoode.

It is easy to see how the neglect complained of has come to pass. In England when mathematics, after having lain dormant for about a century, began to revive, the first necessity was to become acquainted with the enormous amount of work meanwhile done on the Continent. This acquaintance was made through France, at that time nearly all the standard works being in the French language, which was at the same time the language best known to English students. The subjects principally taken up were the calculus and its application to mechanics. And I believe I am not far wrong when I say that the wonderful writings of Lagrange, with their extraordinary analytical elegance, had the greatest influence. But in his works anything geometrical was studiously avoided. Lagrange prided himself that there was no figure in his "Mécanique analytique."

The best analytical methods of the Continent were thus introduced into England, rapidly assimilated and made the foundation of new theories, so that the mathematical activity in this country is now at least as great as it ever has been anywhere.

But whilst analysis, algebra, and with it analytical geometry, made rapid progress, pure geometry was not equally fortunate. Here the hold which Euclid had long obtained, strengthened, no doubt, by Newton's example, prevented any change in the methods of teaching.

Most of all, perhaps, solid geometry has suffered, because Euclid's treatment of it is scanty, and it seems almost incredible that a great part of it—the mensuration of areas of simple curved surfaces and of volumes of simple solids—is not included in ordinary school teaching. The subject is, possibly, mentioned in arithmetic, where, under the name of mensuration, a number of rules are given. But the justification of these rules is not supplied, except to the student who reaches the application of the integral calculus; and what is almost worse is that the general relations of points, lines, and planes in space, is scarcely touched upon, instead of being fully impressed on the student's mind.

The methods for doing this have long been developed in the new geometry which originated in France with Monge. But these have never been thoroughly introduced.

Works written in the German language naturally received even less attention. But it was in Germany, at the beginning of the second quarter of this century, that geometry received at the hands of several masters an impulse which put the subject on an entirely new footing.

I may mention here especially four men of whom each invented a new method and established a new system of geometry. Two of these, Möbius and Plücker, still use algebra, but in perfectly new and original manners, which, although very different from each other, have this in common, that in both we have not algebra interpreted geometrically, but rather geometry veiled in algebraic garb. The geometrical meaning is never lost sight of.

But perfectly independent of algebra was the great Steiner, the greatest geometrician since the times of Euclid, Appolonius, and Archimedes. In

* Delivered at the Southport Meeting, September, 1883.

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his celebrated "Systematische Entwickelungen" he has laid the foundation of a pure geometry, on which a wonderful edifice has since been raised. His treatment of the principle of duality, and his method of generating conics by projective, or homographic, rows of pencils which have been extended to curves of all degrees, have given to geometrical reasoning a generality never before dreamed of. He is in one respect the opposite of Lagrange, hating and despising analysis as much as ever Lagrange disliked pure geometry. Steiner started from the geometry of the Greeks, Euclid's elements, and a few other *metrical* properties he takes for granted; but then he goes on with essentially modern methods of his own to investigate what are now called projective properties of curves and surfaces.

This metrical foundation Von Staudt changed. In his "Geometrie der Lage," published fifteen years after Steiner's "Entwickelungen," he established a most remarkable and complete system, into which the notion of a magnitude does not enter at all. He shows that projective properties of figures, which have no relation whatsoever to measurements, can be established without any mention of them. He goes so far as even to give a geometrical definition of a number in its relation to geometry as determining the position of a point in his theory of what he calls "Würfe;" and one of the most interesting parts of his work is the purely geometrical treatment of imaginary points, lines, and planes.

In the hands of these men, and since their time, pure geometry has become a most important instrument for research, rivalling in power the more or less algebraical methods, and surpassing them all in the manner in which they raise before the mind's eye a clear realisation of the forms and figures which are the object of the investigation.

In close connection with these methods stand descriptive geometry and geometrical drawing, which teach how to represent figures on a plane or other surface. These have been treated as arts unknown at English universities, and relegated to the drawing office. Instead of this they ought to be an essential and integral part of the teaching of geometry in connection with the purely geometrical methods.

In considering the teaching of any mathematical or other scientific subject, we cannot at the present time neglect the wants of the ever-increasing class of men who require what has been called technical education. Among these the large number who want mathematics at all require geometry much more than algebra and analysis, and geometry as applied to drawing and mensuration.

This want has been supplied by the numerous science classes spread over the country, with their head-quarters at the Science and Art Department at South Kensington, whose examinations—now, however, put in competition with those of the City and Guilds of London Institute, and others—have pretty much guided and regulated the teaching. A great deal of good has thus been done, but there is still much room for improvement. The teaching of geometry especially, as judged by the text-books which have come before me, is somewhat deplorable. And this is so, principally, because the spirit of Euclid and the methods of the ancient Egyptians and Greeks, rather than the fundamentally different ideas and methods of modern geometry, still rule supreme; though the latter have had their origin partly in technical wants.

In what is called geometrical drawing or practical geometry, for instance, there are first given a number of elementary constructions, such as drawing parallels and perpendiculars, or bisecting the distance between two given points. They are solved by aid of those instruments only which Euclid knew, viz., the pair of compasses for drawing circles and the straight edge for drawing straight lines. But there is no draughtsman who would not, as a matter of course, use set squares for the former problem and solve the latter by trial rather than by construction. Then, again, there come constructions like the division of the circumference of a circle into seven parts, which cannot be solved accurately, but which is very easily solved by trial. Instead of that, a *construction* is given which takes much more time and is by no means more accurate. For, after all, our lines drawn on the paper are not without thickness, so that for this reason alone every part of the construction is affected by some small error; and it is absurd to employ a construction, though theoretically true, for ideal figures as conceived in our mind in preference to a much simpler one which within our practical limits is equally or perhaps more correct.

This is very much like the manner in which I found problems on decimal fractions treated by the candidates for the Matriculation Examination at the London University, and which reflected little credit on the manner in which the important subject of decimals is handled at our schools. It is so characteristic that I may be excused for giving it here. The problem, for instance, being to give the product of two decimal fractions, exact to, say, four decimals, each of the factors having the same number of places. This was almost regularly performed as follows: First, the decimals are converted into vulgar fractions, then these are duly multiplied, numerator by numerator, and denominator by denominator, and then the resulting fraction is again converted to a decimal, with as many places as it may yield, and, lastly, of these the first four are taken and put down, duly marked *Answer*. Or a candidate, standing however on a far higher level, multiplies both decimals out in the proper fashion, but to eight places, and cuts off four places at the end. No wonder that the public at large will hear nothing of the decimal system of weights and measures if the very essence of the decimal system of numbers is so little understood by the men who have to train the minds of the young generation!

I need scarcely say that I do not mean to blame the Science and Art Department, far less the teachers who have simply to follow suit. They act up to their light, and cannot be expected to introduce methods which are practically unknown at Cambridge, and of which the only good text-books are in foreign languages—books which are probably not at all suitable for introduction into our schools without considerable change.

It is satisfactory to learn that an association has recently been formed under the presidency of Professor Huxley "to effect the general advancement of the profession of science and art teaching by securing improvements in the schemes of study, and the establishment of satisfactory relations between teachers and the Science and Art Department, the City and Guilds of London Institute, and other public authorities."

The good wishes of all who have the cause of sound education at heart must go with such an undertaking, one of the principal aims of which seems to be to save teaching from being any longer enslaved by examinations, and to promote greater accord between the teacher and the examiner. It is to be hoped that this association will consider geometry as one of the subjects included under the designation of science.

It is by the neglect of pure geometry and its applications to geometrical drawing that Cambridge has lost, or rather has never had, contact with the practical needs of the nation. All the marvels of modern engineering have sprung into existence without its help. The great engineers have had to depend to a degree, now unheard of, upon costly experiments, until they themselves gradually discovered mathematical methods adapted to their purposes.

Only the electrical engineer found ready to his hands a complete theory of which the mathematical part has been to a very great extent developed at Cambridge, or by men who have had their mathematical training there. This theory is, however, in its very nature less geometrical. One at least of the great men to whom the present theory of electricity is due, the late Clerk Maxwell, had the keenest appreciation of the value of modern geometry. I remember a characteristic letter of his being read to the Council of the London Mathematical Society, in which the writer, forgetting the subject of his letter, burst out into an enthusiastic praise of a German text-book, the "Geometrie der Lage," by Reye, through which Maxwell, evidently for the first time, got any idea of this subject.

The engineer will always prefer geometrical methods to analysis, and has invented for himself a great variety of them. Originally these are disjointed, being invented for special purposes. It is the business of the mathematician afterwards to connect, simplify, and extend them, as has been done to a great extent by Culmann in Zürich, or by Cremona at the Polytechnic School at Rome.

Of these methods a few may be mentioned. First of all the graphical determination of stresses in certain girders invented both by mathematicians and by engineers. Its application is so simple that no engineer will ever use any other method if once he knows this one. It is so well adapted to its purpose, that I venture to say that a simpler method is impossible, being fully aware how dangerous such a statement is. Nay, if I were asked to give the formulæ to obtain the stresses by calculation, I should write these down from a sketch of the diagram, this being the simplest way of obtaining them.

Another problem which recurs again and again is the determination of the area of a figure representing perhaps a plot of land or the section of a beam. Here also the advantage is altogether on the side of the graphical method.

It is unnecessary to multiply these examples. But to make full use of graphical methods the draughtsman ought to have a thoroughly geometrical education. For instance, the real nature of the reciprocal diagrams already mentioned is only understood by aid of a peculiar reciprocal relation between points and planes in space closely connected with the theory of the linear complex, as has been shown by Cremona.

I have mentioned already the "Analytical Mechanics" of Lagrange, which is without any trace of geometry, although there is scarcely a branch of applied mathematics which is in its very nature more geometrical. In fact, one part of it, now separated as kinematics, treats solely of changes in position and shape of geometrical quantities, and differs from pure geometry only in this, that the changes are considered as referring not to space alone, but also to time.

What mechanics gains by introducing geometry to the full will be apparent to all who have become acquainted with modern Continental text-books on the subject.

Let us compare the analytical with the geometrical reduction of a system of forces acting on a rigid body, or, to use Clifford's nomenclature, the reduction of a system of rotors, which may represent either forces or rotations, or any other quantities which have certain fundamental properties in common with those, so that they may be representated by rotors. In the analytical process the system is reduced to a rotor and a vector, that is a resultant force and a couple. In the geometrical treatment we see that this is only one way of reducing the rotors to two, viz., the one which is best fitted to be treated by analysis. But there is a multitude of other reductions. These all appear as of equal importance in the geometrical method. Furthermore, this method shows us in the simplest way possible how all the line pairs which may be the lines of action of two resultant rotors, although there are infinities of infinities of such pairs, are arranged in space, so that one gets a clear picture of all these reductions in one's mind.

Again, compare Möbius's geometrical investigation of the rays of light passing through a system of lenses with that of Gauss, whose very name suggests simplicity and elegance. The celebrated "cardinal points" appear in Gauss's original paper as the result of a somewhat long though certainly elegant analysis, whilst by Möbius they are the natural outcome of his geometry, so that any student once started on this method is bound to come across these points, or rather across pairs of points, of which the cardinal points of Gauss are only one special case. The whole is, in fact, contained in the following easily proved proposition: The rays of light starting from a point in the axis of the system before entering the first lens, and after leaving the last, form two homographic pencils in perspective position.

This is only one small part of the advantage which optics can derive from geometry.

That the old-established mode of teaching the elements of geometry based on Euclid requires a thorough and fundamental change has been often acknowledged, among others, at Exeter and Bradford, by two of the most eminent mathematicians who have occupied this chair, and besides by the many teachers who constitute the Association for the Improvement of Geometrical Teaching, which itself grew out of the action of our section. I know, therefore, of no opportunity better suited to review the progress made in this direction than the present one, as the subject has on several occasions occupied the attention of our section. Nevertheless, I have hesitated on entering on this somewhat delicate question, because I fear that I have little to offer but criticism, which might seem hostile to the association just named. But I hope that the many earnest workers who have devoted much time and thought to the drawing up of syllabuses on different parts of our subject will excuse the remarks of one who has himself tried his hand at the same work, and who, therefore, may be supposed somewhat to know the difficulties that have to be overcome.

When the syllabus on the elements of plane geometry appeared, I resolved to give it a thorough trial, and took the best means in my power to form an opinion on its merits by introducing it into one of my classes. The fact that it did not quite satisfy me, and that I gave up its use again, does not, of course, prove that it fails also for use in schools, for which it was originally intended.

Let me add that the more I have become acquainted with the difficulty of the whole subject the greater has become my admiration for Euclid's book, whilst my conviction of its unfitness as a school book has equally gained in strength.

In considering the merits of Euclid as a text-book it is desirable to distinguish clearly between the general educational value of its teaching and the gain of geometrical knowledge. It is with the latter chiefly that I am concerned, whilst it is, of course, through the former that Euclid has got so firm a hold at all schools; and to the great majority of boys this is undoubtedly of most importance, and no reform would have the slightest chance of becoming generally introduced which neglects this. But improvement in both directions may well go together, and the logical reason employed in Euclid would gain to many boys much, both in clearness and interest, if the subject-matter reasoned about became in itself better understood.

Probably a great deal could be done by introducing some of the elements of logic into the teaching of language. I have been assured by an eminent scholar that the laws of forming a sentence—the fact that a sentence in its simplest form consists of subject, object, and copula—was not explained in English schools. If this grammatical part of logic were properly treated of in connection with language, and if at the same time acquaintance with geometrical objects, particularly through the medium of geometrical drawing and the many methods used in the kinder-gartens, were more secured, then a systematic course of geometry would become both easier and more useful.

Much, indeed, may be done by introducing simple geometrical teaching into the nursery and into the earliest instruction of children, following the example of the kinder-gartens, and it is pleasing to see that the latter are rapidly gaining ground in England. It is true that these schools may still be improved. In geometry they seem to, and perhaps at present are bound to, work mostly towards Euclid. But many able men and women are actively engaged in perfecting them, and it is of interest to know that Clifford had it in his mind to write a geometry for the nursery and the kinder-garten.

The chief progress in geometrical teaching has to be sought in the introduction of modern ideas and methods into the very elements, and modern teaching ought to take full account of this.

In favour of this view I might bring forward the opinions of many teachers and mathematicians from England as well as from abroad, but I will confine myself to one quotation. Professor Sylvester gives his opinion thus:—"I should rejoice to see mathematics taught with that life and animation which the presence and example of her young and buoyant sister (viz., natural and experimental science) could not fail to impart, short roads preferred to long ones, Euclid honourably shelved or buried 'deeper than did ever plummet sound' out of the schoolboy's reach, morphology introduced into the elements of algebra—projection, correlation, motion accepted as aids to geometry—the mind of the student quickened and elevated and his faith awakened by early initiation into the ruling ideas of polarity, continuity, infinity, and familiarisation with the doctrine of the imaginary and inconceivable. It is this living interest in the subject which is so wanting in our traditional and mediæval modes of teaching."

If from this point of view we now look towards the work of the Association for the Improvement of Geometrical Teaching, the result is not as satisfactory as might have been wished. There is very little of the influence of modern ideas to be found in the different syllabuses which have been published. Even in the one headed "Modern Geometry" there is nothing of the genius of modern thought. The subject-matter is partly taken from modern geometry, but for modern methods one looks in vain. In the geometrical conics, too, one would like to see Steiner's generation of conics, but of these there is no trace.

Nevertheless it is satisfactory to see that the use of the syllabus on plane geometry has spread pretty widely, and it is to be hoped that it will continue to do so. A thorough reform in the direction indicated will be a difficult task, and it will perhaps be a long time before it is possible. At present it has not even been settled which series of axioms will ultimately be adopted. Of the various systems which have been proposed since the investigations of Riemann and Helmholtz I may mention here Clifford's suggestion to replace Euclid's axiom about parallels by the new one, which maintains that in a plane similar figures exist, or, more completely, that at any part in a plane a figure is possible which is similar to any given figure in that plane. This axiom is somewhat startling as long as we have the usual theory of similar figures in our mind. But the notion of similar figures is truly axiomatic, and it has lately become my conviction that this axiom may be extremely fruitful, and the working out of a syllabus of plane geometry based on it would be very desirable.

Possibly many such attempts have still to be made before a new Euclid finds the materials sufficiently prepared for him to raise the hoped-for edition.

BRUSH ELECTRIC LIGHT AND POWER COMPANY OF SCOTLAND (LIMITED).

An extraordinary general meeting of this Company was held at Dashwood House, New Broad-street, on the 16th inst.

The SECRETARY (Mr. F. M. Brockelbank) having read the notice convening the meeting,

The Hon. ASHLEY PONSONBY, who presided, expressed regret at the receipt of a letter from the chairman of the Company, the Earl of Crawford and Balcarres, stating that, though he had intended to be present, he was too unwell to come to London from Scotland. However, so far as the meeting itself was concerned, this was the less important, as the proceedings were really only of a formal nature—simply to consider the confirmation of the resolutions passed at the meeting on the 28th ult. They entered fully into the subject at the last meeting, and therefore it was unnecessary for him to detain them on the present occasion. He concluded by moving the confirmation of the resolutions, as follows:—"That the Company be wound up voluntarily under the provisions of the Companies Acts 1862 and 1867;" and "That the Vice-Chairman, Mr. Robert Ewing, and Mr. Thomas Dickson, be, and they are hereby nominated liquidators for the purposes of such winding up, and that the remuneration of the liquidators be fixed by the shareholders."

Mr. THOMAS DICKSON seconded the motion, which was carried unanimously.

The CHAIRMAN, in announcing the close of business, expressed a hope that the next meeting would be of a satisfactory character.

THE BRAZILIAN SUBMARINE TELEGRAPH COMPANY (LIMITED.)

Report and accounts of the directors to be submitted to the twentieth half-yearly general meeting, 26th October, 1883:—

The directors submit the annexed accounts and balance sheet for the half year ended 30th June, 1883. The revenue for this period amounted to £87,856 11s., and the working expenses to £12,800 9s. 10d. After providing £1,042 16s. 8d. for income-tax, there remains a balance of £74,013 4s. 6d.; to this is added £9,421 0s. 2d., brought forward from the last half-year's account, making a total of £83,434 4s. 8d. A quarterly interim dividend amounting to £19,500 has been paid, and £25,000 transferred to the reserve fund, leaving a balance of £38,934 4s. 8d. The directors now recommend the declaration of a final dividend of 3s. per share, making a total payment of 6 per cent. for the year ended 30th June, 1883, and that the balance £19,434 4s. 8d. be carried forward to the next account. An interruption occurred on the 22nd September in the St. Vincent-Pernambuco section. 260 miles of new cable have been ordered, and arrangements made with the Telegraph Construction and Maintenance Company for the immediate repair of the fault, which the directors trust will be promptly accomplished. The question of duplicating the Madeira-St. Vincent and St. Vincent-Pernambuco sections, which with the duplicate Lisbon-Madeira section laid last year would provide a second line throughout the Company's system, is engaging the earnest attention of the directors, and in view of the necessity for a large and immediate expenditure in repairs and duplications the directors do not think it desirable to make any distribution of profits on this occasion beyond the 6 per cent. above mentioned. Two of the directors, Sir James Anderson and the Hon. W. St. John F. Brodrick, M.P., retire by rotation at this meeting, but being eligible for re-election, they offer themselves accordingly. The two auditors, Mr. Henry Dever and Mr. John Gane, also offer themselves for re-election.

COMPANIES' SHARE LIST.

TELEGRAPHS.

COMPANIES.	CLOSING PRICES Oct. 17.		BUSINESS DONE WEEK ENDING OCT. 17. Highest.	Lowest.
Anglo American	44¾,	45¼	45¼	44¾ x d
Do. Preferred	75¾,	76¼	76	75¼ x d
Do. Deferred	15½,	16	16	15¾
Brazil Submarine	10¾,	11	10 15-16	10⅝
Cuba	10½,	11	10¾	—
Do. Preference	17,	18	—	—
Direct Spanish	5¼,	5¾	—	—
Do. Preference	15½,	16	15¾	—
Direct United States Cable	11¾,	12¼	12¼	12
Eastern Telegraph	10¾,	11	11 1-16	10 13-16 x d
Do. 6 per Cent. Preference	12¾,	13	12¾	12½
Do. 5 per Cent. Debentures, 1899	103,	107	—	—
Eastern Extension	11¼,	11⅝	11⅜	11 9-16
German Union	10,	10½	—	—
Globe Telegraph and Trust Company.	7⅜,	7½	7½	7 5-16 x d
Do. Preference	12 13-16,	12 15-16	13	12¾ x d
Great Northern	12¾,	13⅛	13⅛	12 13-16
Indo-European	31½,	32½	—	—
Mediterranean Extension	1½,	2	—	—
Do. Preference	2,	4	—	—
Reuter's	8½,	9	—	—
Submarine	215,	225	—	—
West India and Panama	½,	1	1	—
Do. 1st Preference	6½,	7	7	6¾
Western Brazilian	5¼,	5¾	5½	5½
West. Union 7 per Cent. 1st Mortgage	122,	124	—	—
Do. 6 per Cent. Sterling Bonds	100,	103	101	—

TELEPHONES.

Consol. Telephone and Maintenance	5-16,	7-16	—	—
Oriental	5-16,	7-16	—	—
United Telephone	8¼,	8¾	8½	8

ELECTRIC LIGHT.

Anglo-American Brush Lgt. (£7 paid).	2½,	2¾	2½	2 3-16
Do. (fully paid)	4,	5	4½	—
Hammond Light (£3 15s. paid)	3½,	3¾	3½	2¾
Eastern Electric (£4 paid)	1,	1½	—	—
Swan	1¾,	2⅛	2 1-16	1⅝
Maxim-Weston	3-16,	5-16	¼	—

MISCELLANEOUS.

Telegraph Construction	35,	35½	35½	34½
India Rubber, Gutta Percha, and Telegraph Works	30½,	31½	—	—

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NOTES.

THE GEODETIC CONFERENCE.—The members of this conference have decided in favour of making Greenwich the first meridian.

UNIVERSITY COLLEGE, LONDON.—The Gilchrist Entrance Scholarship in Engineering has been awarded to Mr. R. F. Hayward.

LIGHTING MILLS.—The Edison Company in Boston, U.S., has contracted to put 200 lights in the Montaup Mills, Fall River, Mass.

BOOK RECEIVED.—"Skizze einer Theorie der Elektromotoren und Elektromaschinen." Von J. A. Lissner. Carl Gerold's Sohn, Vienna.

ELECTRIC TRAMCARS IN BRUSSELS.—A tramcar propelled by the aid of electricity furnished by Faure cells has been running in Brussels recently.

THE JABLOCHKOFF COMPANY.—A petition for the winding up of this company has been presented by Mr. James Willing, jun., of 353, Strand, W.C., and is directed to be heard before Mr. Justice Pearson, on the 10th November.

THE TELEPHONE IN BENGAL.—The Bengal Telephone Company in Calcutta have decided on the employment of female assistants as "operating clerks" in their exchange, and with this object have advertised for candidates.

DIRECT UNITED STATES CABLE COMPANY.—The Board of this company have resolved on the payment of an interim dividend of 5s. per share, being at the rate of 5 per cent. per annum for the quarter ending 30th September, 1883.

THE FISHERIES EXHIBITION.—Amongst the recipients of awards for exhibits at the Fisheries were J. E. Liardet, silver medal; Chadburn and Son, ditto; Julius Sax, ditto; and Telegraph Construction and Maintenance Company, diploma.

FATAL ACCIDENT.—The *Standard's* Pesth correspondent telegraphs that an official of the Hungarian State railways in that city, who, in arranging the electric light, had manipulated the wires carelessly, was instantly killed by the current.

TENDERS FOR ELECTRIC LIGHTING WANTED.—Tenders are being invited for lighting the central square of Spitalfields Market by electric lights. Further particulars can be had of Mr. H. Lovegrove, of 26, Budge-row, Cannon-street, E.C.

DOMESTIC LIGHTING.—The Swan United Electric Light Company are about to light Ismay House, Dawpool, near Liverpool, the residence of one of the managers of the White Star Line. 250 Swan lamps of 20 candle-power will be used.

PROFESSOR REYMOND.—On Sunday last Professor Du Bois Reymond celebrated the 25th anniversary of his professorship at Berlin University. Congratulatory addresses reached him from all parts, including Aberdeen, St. Petersburg, and Upsala.

LONDON-PLATINO BRAZILIAN TELEGRAPH COMPANY.—The revenue of this company for the month of July, 1883, is estimated at £1,585 (Western Brazilian portion £1,052, Land Lines £533), as against £1,231 for the corresponding period of 1882.

UTILISING WATER POWER.—It is said that M. Tommasi intends carrying out some experiments in this direction near Verviers in Belgium. He will utilise water power for the generation of electricity, to be used in turn for driving machines and producing light.

CABLES INTERRUPTED.—The Eastern Telegraph Company notifies the interruption of the duplicate Java-Australia cables. Telegrams for Australasia will be accepted at the senders' risk, to be sent on as soon as the communication is restored, or by first steamer.

AMALGAMATION.—Something has driven the Gas Light and Coke Company and the South London Gas Company to amalgamate. The Edison and Swan Companies have united, and the Hammond Company is gathering under its wings such of its chickens as still retain a spark of vitality.

CODE TELEGRAMS FOR SPAIN.—The Direct Spanish Telegraph Company notify that the use of code or cypher in telegrams, which was prohibited by the Spanish Government in August last, is now permitted, and that telegrams in cypher can therefore be forwarded to all places in Spain.

THE CABLES PROTECTION CONFERENCE.—M. Cochery, French Minister of Posts and Telegraphs, and President of the Conference, gave a dinner on Friday night, the 19th inst., at the Ministry of Posts and Telegraphs, to the members of the Conference, at which M. Jules Ferry and others were present.

ELECTRIC CARBON STORAGE AND APPARATUS MANUFACTURING COMPANY.—Mr. Justice Pearson has appointed Mr. John Evans Jackson to be the official liquidator of the above company. Creditors are required to send particulars of their claims to Mr. Jackson, at Exchange-buildings, Leith, N.B., before the 2nd November.

ELECTRIC LIGHT IN BELFAST.—Messrs. J. and T. M. Greeves and Co., of the Fourth River Flax Mills, have decided to light up their new premises by the electric light. Mr. J. H. Greenhill, of Belfast, has received instructions to make a Bürgin dynamo for this installation, and supply 120 Swan 20 candle-power lamps.

TELEPHONIC COMMUNICATION.—The Ramsgate Improvement Commissioners want tenders for supplying telephonic communication between various points in the town and the gasworks, &c. Tenders are to be sent in by the 5th Nov. Further particulars can be had of Mr. W. A. Valon, engineer to the commissioners, at Ramsgate.

A HEAT INDICATOR.—M. Tommasi has devised a small apparatus for giving warning of the heating of a circuit wire. The idea is that before the wire becomes too hot it melts an insulator between it and the apparatus. When the insulator is liquified the wire coming in contact with the apparatus completes the circuit of a bell, and so warning is given.

CANADIAN TELEGRAPHS.—The press of Canada is agitating for the assumption by the Government of the entire telegraphic system of the country. The Montreal Board of Trade, the most influential organisation of the kind in Canada, made a strong expression of opinion at its quarterly meeting in favour of Government control, at the same time pointing out the advantages arising from the adoption of the system in Great Britain.

THUNDERSTORM AT DUNFERMLINE.—During a thunderstorm at Dunfermline (Scotland), on Friday, the 19th inst., the lightning completely demolished seventeen feet of a wall fourteen feet high, in the suburb of Brucefield, whilst forty feet long by six feet in breadth of the bank against which it was built was carried away. A part of the public thoroughfare was also torn up and several trees were uprooted. Fortunately no person was passing the spot at the time.

DESIGNS AND TRADE MARKS.—The President of the Board of Trade has appointed Mr. T. L. Whittle to be Registrar of

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Designs and Trade Marks, under the Comptroller-General of Patents, Trade Marks, and Designs; and has instructed him to visit Manchester, Glasgow, Birmingham, the Potteries, Nottingham, and Bradford, so as to confer with the Chambers of Commerce at those places upon the registration of designs and trade marks under the Act of last Session.

German Cables.—During the past summer the German Government have laid a cable from Emden to Norderney, one of the North Sea bathing resorts. They also contemplate laying another to the island of Borkum, in order to meet the increase of traffic with both these places during the bathing season. In addition to the foregoing, a length of underground cable has been laid through the town of Emden. This dispenses with all aërial wires through the town itself, a telephone wire only remaining.

A Large Rheostat.—The rheostat used by the committee of the Munich Electrical Exhibition in testing machines, &c., mentioned in our issue of the 6th instant, p. 497, consisted of wires supported on porcelain insulators fixed to a large frame erected in one of the galleries of the exhibition building. The frame was 60 meters long (192ft.), and consisted of several rows of vertical posts, fitting into crossbeams overhead. This explanation may serve to elucidate the remarks in our article, which might otherwise require some thought.

Telegraphic Extension in Tasmania. — Telegraphic communication has been extended between Waratah and Corinna, and the overseer on the West Coast has been engaged in erecting a line between Trial Harbour and Macquarie Harbour. Considerable progress has been made with the construction of the main road between Waratah and Mount Heemskirk. A party of sixty-four men are now engaged in clearing from Waratah Head in order to facilitate communication with Specimen Reef. This work is being carried out under votes sanctioned in 1882, and amounting to £6,500.—*Colonies and India.*

Music by Telephone.—On the occasion of the Musical Festival at Leeds, which took place last week, Mr. J. C. Chambers, general manager of the National Telephone Company's Exchange in that town, had the hall where the singing was going on connected with his offices by a telephone line. Three transmitters were placed in the hall, and sixteen receivers in Mr. Chambers's offices. Ten transmitters in the hall were also connected with receivers in the neighbouring towns of Bradford, Dewsbury, and Huddersfield. The music and voices are reported to have been very distinctly heard by small but enthusiastic audiences.

West India and Panama Telegraph Company.—According to the report of this company for the six months ended June 30 last it appears that the amount at credit of revenue was £52,641 1s. 1d., and the total available balance, including the sum brought from last account, £28,472 4s. 3d. Of this £20,000 has been placed to reserve, which now amounts to £81,843 13s. 7d., and a payment is recommended of 3s. per share on account of arrears of dividend on the First Preference shares, leaving £3,287 15s. 3d. to be carried forward. The colony of Trinidad has increased its subsidy to the company from £2,500 to £6,000 per annum.

Great Marlow.—A *conversazione* was held here on Tuesday evening, in connection with the Mutual Improvement Society, when Mr. Edwin Clark, M.I.C.E., the president, exhibited a large assortment of electrical apparatus, and with the assistance of Mr. A. J. Frost carried out a series of interesting experiments with the microphone, which created considerable interest. Mr. Frost, who arranged these experiments, also exhibited Lemoine's electro-magnetic clock, a description of which we hope to publish in a future number. Most of the apparatus used was of the simplest character; but the experiments were very successful, and the result showed that a large amount of instruction and amusement can be obtained from simple and inexpensive materials—cigar-boxes, to wit.

Improvements in Accumulators.—We are informed by the Electrical Power Storage Company that they have effected some valuable improvements in the construction of their accumulators. In future boxes will be dispensed with, as also the metallic connections in the battery from cell to cell. The superficial area occupied by the accumulator is reduced to a minimum, and no doubt is entertained that the new type will be regarded by the public as adding greatly to the convenience and utility of electrical accumulators. The company hope that their factory will be able to turn out these accumulators by January next. In the meantime, unless in cases where it is absolutely necessary for the commencement of contracts, the company desire to withhold the supply of the present type. The new construction will, we are informed, allow a reduction in the prices of the accumulator.

Electric Lighting at Brussels.—On the occasion of the opening of the magnificent new Palais de Justice at Brussels, which took place last week, there was a profuse display of electric lights. The dynamos were situate in the Rue de la Regence, a short distance from the Palais. They were driven by a semi-fixed Robey engine of 65 h.-p. Altogether 15 Gramme machines were used. Nine Jaspar arc lamps were so placed as to throw their light on to the front of the building, whilst four others were so arranged as to throw their light upwards to illuminate the architecture of the entrance. In the dome inside the building was placed a Fourment arc lamp with projector, which lit up the space beneath. The machine room was lighted by means of two Gramme arc lamps. The total length of the circuits was 3,200 metres. The work was carried out by the Compagnie Generale d'Electricité, under the direction of M. Nothomb.

Water as a Motive Power.—It has occurred to a gentleman resident in Georgetown, West Indies, that a possibly valuable source of energy is allowed to run to waste in the tropics in the shape of the water which pours off the roofs of the houses whenever there is a shower. The gentleman in question, in a lecture delivered recently before a local society, said that "Having been frequently struck by the great volume of water discharged from roofs during heavy tropical rains, it occurred to me that the power so wasted might be utilised in some way by converting it into electricity by the following means:—The water from each roof might be conducted into one main downpipe, in which would work a small turbine wheel driving a dynamo-electric machine, the electricity so developed by every passing shower to be stored in accumulators of the type of Faure's secondary batteries. These as they became charged in variable time, depending on the rainfall, could be collected and stored at central depots, from whence the power could afterwards be distributed uniformly, either by electro-dynamic engines, or utilised directly for electric lighting!"

A Lofty Telephone Station.—On the topmost height of Red Mountain a slight prominence, that looks no larger than a bushel basket, can be seen, which is a telephone station established by the Central Pacific Railroad Company. This is a house occupied by two watchmen, who are on the outlook for fires in the snow sheds. They can take in the whole line of snow sheds with their natural sight and by the aid of glasses. If they observe a fire in or near the sheds on any part of the line, they immediately notify the station at

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Cisco by their telephone line, and forthwith the information is sent by telegraph to the railroad station at Sacramento, and in a minute or two the order is sent up the line to Blue Canon, and the Summit, where the trains are constantly on duty, to proceed to the point where the fire is prevailing. The fire train consists of a locomotive, with two tank cars filled with water, which is thrown with hose by a steam force pump. When the fire trains are sent out they have the road, all other trains near the point of danger being stopped. The services of these fire trains are frequently called upon, but they are so prompt in action that they generally subdue the fires before much damage is done.—*Electrical World.*

The Dispersion of Light.—M. C. E. de Klercker has recently combined the results of his researches on the dispersion of light in a memoir which has been presented to the Paris Academy of Sciences by M. Fizeau. He has considered the question from an exclusively physical point of view. His theory is founded on the hypothesis of envelopes of compressed ether surrounding molecules of matter, and on the ideal union of all these envelopes, forming in the refracting medium simple cushions of medium density. It explains the phenomenon of dispersion by admitting that in compressed ether, in conformity with that which takes place in free ether, the speed of propagation is invariably the same for different luminous rays. In place of the expression—

$$\omega = (1 + A)\frac{L}{L - B},$$

previously given as the formula for dispersion, he now writes,

$$\omega = \frac{1 + A}{2}\,\frac{2L^2 - LB}{L^2 - LB - C}$$

or with equal precision,

$$\frac{1}{\omega^2} = \frac{1}{(1 + A)^2}\left(1 - \frac{B}{L} - \frac{C}{L^2}\right)$$

or a formula very like this, but less applicable in practice, which is,

$$\frac{1}{\omega^2} = \alpha - \frac{\beta}{L} + \frac{\gamma}{L^2} - \frac{\delta}{L^3}.$$

The co-efficients of the new formula are composed of numbers the numerical values of which depend upon the chemical and physical state of the refracting body, and also, to a certain degree, of the transparent material medium which surrounds this body. The theory also leads to the generally known empirical formula

$$\frac{\omega - 1}{\delta} = \text{const.}$$

for the refracting power of an isotropic medium.

The New Patent Law.—With the object of affording information to the public until the new rules under the Act are completed, the following directions have been issued by Mr. H. Reader Lack, by order of the Board of Trade: "1. Applications and all other documents will be required upon strong wide-ruled foolscap paper (written or printed on one side only), having a margin of two inches on the left hand part thereof. The use of parchment will be discontinued. Copies of specifications will no longer be required. 2. The sizes of the drawings will remain unchanged, but they will be required upon drawing paper instead of on parchment. A copy of the drawings will be required upon thin Bristol board. 3. Forms of application (stamped) will be placed on sale at the chief post offices in the United Kingdom. 4. The forms required for an application will be—(*a*) for provisional protection: Application form and form of provisional specification; (*b*) for complete protection: Application form and form of complete specification. Where a complete specification is not left in the first instance, it may be left at any time within nine months after application for provisional protection. 5. The fees will be £1 for each stamped form of application, and £3 for each stamped form of complete specification. No fee will be charged for the form for provisional specification. 6. Applications may be left at the Patent Office or sent by post. If sent by post they must be addressed to the Comptroller, Patent Office. 7. The 'declaration' in the application form must be made by the inventor or inventors. All other documents may be prepared and signed by agents. Note.—'Applications' for letters patent made during the present year must be proceeded with in accordance with the existing laws and rules."

The Holborn Restaurant.—After a long season of renovation this well-known restaurant was publicly opened on Monday last. The rooms are now, perhaps, more finely decorated than those of any other public place in England, or, for the matter of that, on the Continent or America. We cannot, however, enter into details of the use of marble and of the architectural beauties—that must be left for others. What we have specially to note is that the building is lighted throughout by the electric light—the Edison system is used, as our readers already know. The brasswork for the electroliers and other ornamentation has been carried out by Messrs. Verity and Sons, of King-street, Covent Garden. The resources of this establishment have been taxed to the utmost to design work in accordance with the various requirements. The electroliers in the Venetian Room were designed after careful consideration of the Venetian style of ornamental work. The brackets in the Holborn entrance are facsimiles of brackets designed in the last century for Marie Antoinette, and are, we think, extremely fine. The brass balustrade round the balconies is unique, and we understand no such use has previously been made of brass. The whole of the *repoussé* panels are beaten out by hand from the sheet metal, and have taken considerable time to execute, the designs of the panels being constantly varied. In this room there are 48 small electroliers, and eight large ones, in the Italian *renaissance* style, making a total of 56 in one room. The whole of the brass work is lacquered by a peculiar process, so that it is difficult to distinguish it from gilding, for which it has often been mistaken. We might mention the cast "*grilles*" in Maple's screen. These the firm classes with the finest work they have made, the design being in the *renaissance* style. They have been designed and modelled throughout by a French artist. There is no doubt that the Holborn Restaurant, which has long been a great attraction, will in future rank as one of the necessary sights of London.

Electric Light for War Purposes.—The Vienna correspondent of the *Standard*, telegraphing on Monday night last, says:—"An interesting experiment with the electric light for the purpose of searching a battle-field for dead and wounded was tried this evening outside the city, in the presence of the Crown Prince, the Archdukes Albrecht and Wilhelm, and a number of high military officials, as well as a large assemblage of the general public. An arc light of a hundred and sixty thousand candles was placed on the top of the eastern gate of the Rotunda, and by means of an immense reflector the rays were thrown on the adjoining plain, commonly used for trotting matches. At the opposite end of the course was another arc light mounted on a car, and provided with a powerful reflector, the whole being specially manufactured by Sauter and Lemonnier, of Paris; whilst the centre of the ground was occupied by six ambulance transport carts and sixty field litters. Sixty medical students, scattered over the plain,

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represented the dead and wounded, and a staff of fifteen doctors, assisted by a hundred firemen as bearers, were employed in searching the ground, attending to the wounded, and carrying them on litters to the ambulance carts. The whole was accomplished in a few minutes, but as the places where the subjects were lying were tolerably well known, and as the ground was level and free from trees or undergrowth, the value of the experiment from a military point of view cannot be very great. Another objection is that the great arc light was too strong, brilliantly lighting up a certain portion of the field, whilst the rest seemed even darker from the contrast than before. It would seem that a number of smaller lights scattered over the field would be more useful. For practical purposes, at least a hundred of these would be required, and this would constitute a very serious augmentation of the train which every effort of modern military science is directed to reduce. The experiments will be continued with such modifications as are suggested by experience."

Electric Lighting in the City.—At the meeting of the City Commissioners of Sewers, on Tuesday, the Electric Lighting Committee brought up a report stating that the proposals by the companies with a view to contracts to be embodied in the commissioners' license had been so vague and unsatisfactory, that it had been found impossible to come to any terms, except with the Edison and Gülcher Companies. The Edison Company proposed to enter into a contract for the Holborn-viaduct and the General Post Office, and they would supply the public lamps within the area on the same terms as those now in force with the Gas Company. To private consumers they proposed to charge at a maximum rate of 9d. a unit. The Gülcher Company proposed to light, compulsorily, a certain area, including Bishopsgate-street, from Threadneedle-street to Houndsditch, and Aldgate High-street. They suggested also a large permissive area. For street lighting the maximum charge would be £1 5s. per quarter for the current necessary for each 20 candle-power nominal Crookes incandescent lamp, £2 7s. 6d. for each 40 candle-power lamp, and £12 10s. per quarter for each Gülcher arc lamp of 2,000 candle-power nominal. For private lighting the price would be 8½d. per commercial unit. For carrying the wires into private houses the company would charge for each Crookes lamp at 5s., and in addition the customer would have to pay for fixing at a rate per foot of wire, depending on the number of lamps and the cost of excavation, breaking walls, ceilings, &c., and making good. As regarded the public lighting, it was estimated that the proposal of the company would provide at least 30 per cent. more light than was now received from gas at the same cost. In submitting the proposal of the two companies as the basis of provisional agreements to be entered into with them in view of the application to the Board of Trade for a license, they were not unmindful of the fact that the commissioners in obtaining such license would assume to themselves serious responsibilities, failing the completion and proper fulfilment of agreements by the companies, but they were advised that the proposals were in themselves fair and reasonable, and they therefore recommended that they should be accepted, conditional upon sufficient guarantees being furnished by the companies.—Mr. Stoneham moved the adoption of the report, and, after a discussion, it was carried, with a rider by Mr. Innes, that in agreeing to the report, the commissioners directed the Streets Committee to proceed with public and private lighting in parts not covered by the electric lighting companies.

Overhead Wires in Wandsworth.—The case of the Postmaster-General *v.* the Wandsworth District Board of Works (*vide* our last week's notes) came before Mr. Paget again on Saturday last. As our readers will remember, the Postmaster-General has taken out summonses against the Board for refusing to allow him to erect overhead wires. The proceedings are interesting as being the first in which a magistrate has been called upon to decide a dispute between the Postmaster-General and a local authority. On Saturday Mr. Henry Eaton was recalled, and gave evidence for the Postmaster-General to the effect that in the case of the Tooting circuit the wires could not be carried underground along the same course. They had no right over private property. He also said that there had been no difficulty with other boards with regard to overhead wires with the exception of two or three instances.—On behalf of the Board Mr. James Barber, the surveyor for Streatham and Tooting, was called, and mentioned several accidents which had occurred in his district. On one occasion a young man was knocked down and killed at Balham-hill. He came to the conclusion that overhead wires were dangerous and a nuisance.—Mr. George Street, a builder and a member of the Board, said a wire which was stretched between two posts fell across the road in Latchmere-street, Battersea.—Mr. Corsellis, who appeared for the Postmaster-General, produced a portion of the wire, which was in a very rusty condition. Other witnesses were called, who gave evidence as to accidents in Putney, Roehampton-lane, and Clapham.—Mr. Corsellis, in the questions which he put to the witnesses, endeavoured to show that many of the wires did not belong to the Postmaster. He said that in the London district there were twenty times as many wires belonging to private persons as to the Postmaster.—Mr. Paget, at the conclusion of the evidence, thought that between two public bodies, in the interests of the public at large, an arrangement might be made as to where the poles should be placed, and the case amicably settled. It seemed to him that he must decide in favour of the Postmaster, the additional expense of placing the wires underground being so great, besides interfering with the strange anatomy of pipes which was to be seen on any ground being opened.—Mr. Lane, who represented the defendants, addressed the bench, and pressed upon the magistrate to consider that the additional expense was far outweighed by the danger of increasing the number of wires. He thought the Board were justified in coming to the Court and asking that the danger might not be increased.—The summonses were then adjourned for an arrangement, Mr. Paget stating that if he were pressed for a decision he should report in favour of the Postmaster.

Earthquakes.—We have a long list of earthquakes to add to that published in our last issue, but the range over which the shocks have been felt appears to have narrowed considerably. The western shore of Asia Minor and the Mediterranean coasts are the localities which have been chiefly affected. A Reuter's telegram from Constantinople, dated October 18, said that slight shocks of earthquake continued to be felt at Chios, and in the neighbourhood of Tschesme. A telegram from Gibraltar on the 20th inst. stated that three shocks of earthquake following in quick succession were felt there shortly after midnight on the 19th inst., and another at two o'clock on the morning of the 20th. The direction of the shocks was north to south. A shock, lasting three seconds, was also felt at Tangier on the opposite coast, at half-past one a.m. on the 20th. Shocks of earthquake were felt at a quarter to one o'clock on Friday night, the 19th, at Huelva, Cadiz, Medina Sidonia, Jerez, and other districts of Andalusia along the ocean coast. The movement was from east to west. Telegrams from Huelva and Cadiz

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say a rumbling noise accompanied the earthquake, which is said to have lasted three seconds in some places, and five seconds in others. In Cadiz the shock is described as strong enough to move doors and bells. No damage is reported to life or property. The weather, which was unusually wet, with cold winds early in October, had lately become very mild and warmer in the south of Spain. Several slight shocks of earthquake were felt in Lisbon on Saturday morning. On Sunday shocks at Tschesme were reported to be still coming in irregular succession, each one, however, being fainter than the last. The "Volta," cable ship, belonging to the Eastern Telegraph Company, sailed from Constantinople on Saturday with relief for the sufferers at Smyrna and Tschesme. Telegrams received by the *Daily News*, dated Smyrna, Monday morning, stated that the shocks at Tschesme still continued. The same paper's correspondent also reports that the shocks were felt at Smyrna, where several buildings have been greatly damaged, the Ottoman and English telegraph buildings particularly, so that the officials refuse to work longer on account of the oscillations. A new building has been hired. Further on he says : — "While writing this I am nearly thrown out of my chair. The 'Téméraire' and 'Monarch' arrived here this morning. The 'Helicon' has just left to join the flagship at Chio. The Eastern Telegraph Company's ship 'Volta' has just arrived, and leaves to-night with several tons of food for the sufferers. The English admiral has offered the help of the squadron." On the same day, viz., the 22nd inst., a slight shock is reported to have been felt at Malta at 2 a.m., no damage being done, however. Two shocks also were felt the same morning at Belluno, at the foot of the Dolomite mountains in Italy. The first was at 3:35, the second at 4:15 a.m. Much alarm was caused, but no damage was done. Belluno suffered great destruction from the earthquake of 29th June, 1873. Trieste was visited by an undulatory motion of the earth at 3:30 a.m. the same day. On the 23rd and 24th inst. telegrams from Constantinople stated that shocks were still felt at Tschesme and Smyrna, those at the latter place being of a violent character.

Tampering with Telegrams.—At the Manchester City Police-court on Thursday week, before Mr. F. J. Headlam, stipendiary magistrate, Henry Hulme (compositor), William Brittain (newspaper publisher), John Edwin Garside and Septimus Lockwood Lamb (telegraph clerks) were charged on remand, Garside and Lamb with making known the contents of certain telegrams, and Hulme and Brittain with conspiring to obtain certain telegrams the property of the Postmaster-General. We reported the preliminary proceedings in this case in our last issue. In the course of the evidence for the prosecution Henry William Cribbett, a telegraph clerk at the Central Telegraph Office in London, stated that he was engaged at the Sandown Race Course Telegraph Office on the 4th of September. In the course of his duty he received a message at 2:40. He marked the time on the message, and handed it over after he had punched it along with a perforated slip to another clerk, named Walker, to be sent to Manchester. The messages were usually sent off the moment they were received.—Robert Stableford, a clerk at the telegraph office at Manchester, stated that the message (produced) was the official message of the Sandown Autumn Cup, which should have been transmitted to the newspapers.—Mr. Frank Mottram, assistant superintendent of the chief telegraph office, Manchester, said a man named Carmichael was working the Sandown wire. On the same desk was the Curragh wire, next to that being the *Evening Mail* wire. The Curragh wire was 3ft. from the Sandown wire, and the Sandown wire 3ft. from the *Evening Mail* wire. He saw Garside at the Curragh wire, which was his proper circuit. A man standing at the Curragh wire could not read the messages coming from the Sandown wire, unless he could read by sound. He could not read the slips without taking them in his hand. Lamb was in the news room on the afternoon in question, immediately behind the racing circuit.—Robert Wm. Mason, also an assistant superintendent at the chief office, Manchester, said neither the original message handed in at Sandown nor that which should have been sent to the *Evening Mail* could be traced. It never occurred to him, although he knew of these proceedings, to take measures for the preservation of the copies of the messages, which could not now be traced.—Mr. H. S. Green, reporter on the *Manchester Courier* and *Evening Mail*, stated that certain inquiries were set on foot on September 6. Witness was present when the prisoner Hulme was called into the office of Colonel Sowler, the proprietor of those papers. In answer to some questions put by witness, Hulme said he met a man, who was called "Toby," in a beer house. "Toby" made an offer to him (Hulme) to supply him with the names of the winning horses of certain races. That occurred a short time before the Stockton races. The first information he received was about Stockton races. The result of the information he received was such that he was "bitten," and he would have no more to do with the transaction. Later on in the same day Brittain was called into the office. He was told he was receiving telegraph messages from the boys in the *Evening Mail* room, containing results of races. When pressed, he said all he had received from betting on races was £4.—Albert Taylor, formerly an office boy in the *Evening Mail* office, said he worked the telegraph instrument at the *Evening Mail* office in connection with the chief telegraph office. He remembered the Goodwood races, beginning on Thursday, July 31. He worked the wire for the meeting. Hulme told him he had met Lamb. He said he was a telegraph clerk, and was to be called "Toby." Hulme told witness "Toby" was to send the names of the winning horses, in advance of the official message, to him. Hulme asked witness to receive messages in advance of the official message. Witness accordingly did so, receiving about a dozen, and gave them to Hulme. Witness remembered that Laceman was the name of one horse he received through the wire. He communicated it to Hulme five or six minutes in advance of the official message.—To the Magistrate: The Wilton Club was about 100 yards from the *Evening Mail* office. Witness gave him the information. He rushed out of the office. In addition to giving Brittain the official message, witness handed over messages from "Toby" to him. Brittain and Hulme were out together when these messages were given. Brittain told witness that when he (witness) received a message from "Toby" he was to answer "Judy."—Frank Lyons, also formerly an office boy at the *Evening Mail* office, gave similar evidence to that of Taylor. He informed Hulme of the results of races. Evidence was also given by a newsboy named Field, who stated that some time ago he arranged with the prisoner Brittain to wait outside the *Evening Mail* office, and when he received a piece of paper from the witness Taylor, he was to run to the Prince of Wales's Betting Club, where he was to meet Brittain, and give it to him. This closed the evidence for the prosecution, and the prisoners were committed for trial at the assizes. An application by Hulme's solicitor for bail was refused. The other prisoners were allowed out on bail, two sureties of £50 each being accepted for their appearance.

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CURRENT ENERGY.—IX.

BY OLIVER HEAVISIDE.

(CONTINUED FROM PAGE 511.)

In the first place, if there were only the Peltier effects in a circuit of two metals, *a* and *b*, we should have $P_1Q/t_1=P_2Q/t_2$, where t_1 and t_2 are the absolute temperatures of the junctions, t_1 being the higher, P_1 and P_2 the Peltier forces, both reckoned from *a* to *b*, and Q the quantity of electricity passing whilst P_1Q of heat was absorbed at the hot and P_2Q generated at the cold junction; or $P_1/t_1=P_2/t_2$. And, this holding for any two temperatures, the quantity P/t should be the same for all temperatures, a constant depending upon the nature of the two metals concerned, $=p$ say. Hence $P=pt$ would express the Peltier force at any temperature *t*, and the thermo-electric force of the circuit would be simply $E=P_1-P_2=p\,(t_1-t_2)$, and therefore be proportional to the difference of temperatures of the junctions, whatever their absolute values might be.

This formula for E is nearly true for small differences of temperature when we keep t_2 constant and raise t_1. But the value of *p* must be taken differently according to what the mean temperature is. And the fact of inversion of current with many pairs of metals shows that the formula is quite wrong for wide ranges of temperature.

But now apply the second law to both the Peltier and the Thomson effects. Let σ_a and σ_b be the E.M.F.'s from cold to hot in *a* and in *b* per degree of rise of temperature. Then σ_aQ and σ_bQ are the heats absorbed when Q passes from cold to hot. Hence, taking Q as the unit of electricity for simplicity,

$$\frac{P_1}{t_1}-\frac{P_2}{t_2}+\int_{t_2}^{t_1}\frac{\sigma_a-\sigma_b}{t}\,dt=0 \quad . \; . \; . \; . \; . \quad (3)$$

expresses the second law. We have the $-$ sign before P_2, because both P's are reckoned from *a* to *b*, and the $-$ sign before σ_b, because both σ's are reckoned from cold to hot, whilst the current must go from *a* to *b* at one junction, and from *b* to *a* at the other, and from cold to hot in one metal, and from hot to cold in the other.

Equation (3) holding for any two temperatures, let the range be 1°, the mean temperature being *t*, and $t_1=t+\frac{1}{2}°$ $t_2=t_1-\frac{1}{2}°$. We thus get, (or by simply differentiating (3)),

$$\frac{d}{dt}\left(\frac{P}{t}\right)+\frac{\sigma_a-\sigma_b}{t}=0 \quad . \; . \; . \; . \; . \quad (4)$$

which expresses the difference of "specific heats of electricity" in the two metals in terms of the variation of P/t with the temperature. Let *b* be a metal in which there is no reversible heat effect, *i.e.*, let $\sigma_b=0$. Then by (4) we see that, if the Peltier force divided by the temperature varies with the temperature, its increase per degree equals the Thomson E.M.F. from hot to cold divided by the temperature.

By means of the relation in (4) we may eliminate the Thomson forces from the equation of E.M.F. This is,

$$E=P_1-P_2+\int_{t_2}^{t_1}(\sigma_a-\sigma_b)\,dt,$$

from *a* to *b* at the hot junction. Put for $\sigma_a-\sigma_b$ its value in terms of P by (4) and integrate, and there results simply

$$E=\int_{t_2}^{t_1}\frac{P}{t}\,dt \quad . \; . \; . \; . \; . \quad (5)$$

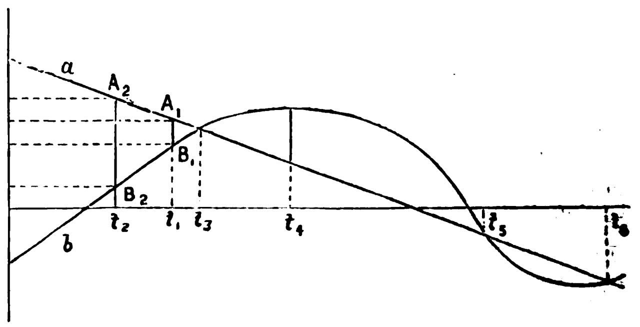
which is Sir W. Thomson's expression for the complete E.M.F. in a circuit of two metals in terms of the Peltier force only at the temperatures intermediate between those of the junctions. In words, the thermo-electric force equals the product of the difference of temperatures of the junctions into the mean value of P/t between t_1 and t_2.

Let the range be 1°, $t_1=t+\frac{1}{2}$, $t_2=t-\frac{1}{2}$. Then we get simply $E=P/t$. In fact, the Thomson effect decreases indefinitely in comparison with the Peltier effects at the junctions as the difference of temperature is made smaller and smaller. This all-important quantity P/t is called the thermo-electric power. It depends upon the nature of both metals and on the temperature.

Thus, we do not need to measure the Peltier and the Thomson effects to determine the E.M.F. in a circuit, but merely require to know how P/t varies with the temperature, and that may be found by observing the current in the circuit due to both P's with a small difference of temperature, and varying the mean temperature.

It is convenient to refer all metals to a standard metal in which $\sigma=0$, whether such a metal really exist or not. Then, in a circuit made up of any number of different metals, the complete E.M.F. $=\Sigma\int\frac{P}{t}\,dt$, the summation including all the metals, each integral being taken between the terminal temperatures, for the metal concerned. P here is not now the real Peltier junction force from one metal to the next, but what it would be if the next metal were the standard. If all the junctions are at the same temperature, every integral vanishes, and there is no resultant E.M.F., the Peltier forces being exactly counterbalanced by the Thomson forces. And it follows that if any circuit be cut anywhere, and the ends joined through a series of metals whose junctions are all at the same temperature, the terminal conductors of the series being of the same metal, no change will be made in the E.M.F., *i.e.*, the E.M.F. of the new circuit is the same as that of the old. Of course there are additional reversible thermal effects introduced, but they exactly balance in the sum.

Further progress is facilitated by representing the changes in the thermo-electric powers P/t of different metals continuously in a diagram. Measuring temperatures from left to right, and the powers upwards, the power of any metal for all temperatures will be represented continuously by a line,



which may be straight or curved for all we know without experiment. Sir W. Thomson's first thermo-electric diagram consisted of a number of lines which were all quite straight except that for brass, which shows some curvature. It has been confirmed by Professor Tait's experiments that with one or two exceptions the lines of thermo-electric power for all the metals are sensibly straight within wide ranges of temperature, with one or two exceptions. For generality we may take one straight and the other curved.

Let the temperatures be measured along the horizontal base line, let the straight line *a* be the line of thermo-electric power for a metal *a*, and the line *b*, partly straight and partly curved, be that for a metal *b*, both referred to a standard in which $\sigma=0$. Pair *a* and the standard, and let the junctions be at temperatures t_1 and t_2. The verticals A_2t_2 and A_1t_1 present the power of *a* at those temperatures. Therefore the rectangles $A_2a_2Ot_2$ and $A_1a_1Ot_1$ represent the Peltier junction forces. Their difference is the excess of the area $A_1t_1t_2A_2$ over the area $A_1a_1a_2A_2$. But the mean value of the power of *a* multiplied by the difference of temperatures, which, by what was said before, is the total E.M.F., is represented by the area $A_1t_1t_2A_2$. Hence, since there is no Thomson E.M.F. in the standard metal, the area $A_1a_1a_2A_2$ represents the Thomson E.M.F. in the metal *a*. Similarly, by pairing *b* and the standard, the areas $B_1b_1Ot_1$ and $B_2b_2Ot_2$ represent the Peltier forces at the same temperatures t_1 and t_2, and the area $B_1b_1b_2B_2$ the Thomson integral force in the metal *b*.

Finally pairing *a* and *b*, the areas $A_1a_1b_1B_1$ and $A_2a_2b_2B_2$ show the Peltier forces, and of course the Thomson integral E.M.F.'s are as before. The complete E.M.F. in the circuit

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is the area $A_1A_2B_2B_1$. As regards the directions these four forces act in the circuit, it is only necessary to remember that they all act from places of higher to places of lower power, therefore from A_1 to B_1, and from A_2 to B_2 at the junctions, and from A_2 to A_1 and from B_1 to B_2 in the metals *a* and *b* respectively.

In the case illustrated, the Thomson forces predominate, and the current circulates in the direction $A_1B_1B_2A_2A_1$. When the higher temperature is raised to t_3, the lines cross, the metals are neutral to one another, the Peltier E.M.F. vanishes, and the current is a maximum. Further increase of temperature of the hot junction (keeping t_2 constant) reduces the current, because the Peltier force at the hot junction acts now from *b* to *a*. When the temperature of the hot junction reaches t_4 the current vanishes. Above t_4 it comes on again in the reverse direction, and gets stronger and stronger until t_5 is reached, where there is a second crossing of lines of power and maximum current (negative). From t_5 to t_6 the current gets weaker and at t_6 reaches a minimum and begins to increase again. As the lines extend no further, we cannot say what will happen with further rise of temperature.

(TO BE CONTINUED.)

MACHINE BANDING.

BY T. H. SEYMOUR HAWKER.

In the numberless applications of mechanical devices to industrial purposes no subject is more relegated to mere guesswork and "rule of thumb" than the transmission of power by banding, and it is much to be regretted that this conventional laxity is being allowed to creep into the practice of the electrical engineer.

Even a slight experience with the countershafting necessary in driving high speed dynamos from low speed motors will suffice to show the uncertainty that prevails in present practice, and to make it apparent how essential it is that the frequent alterations of plant, involving deplorable loss of time and money, should be avoided by a systematic calculation of the dimensions and ruling factors necessary to insure adequacy of driving power. The subject does not present much difficulty; indeed, its apparent simplicity has probably caused its proper study to be neglected.

The principal obstacle is the large range of variation of conditions possible, and the inability, by any exact yet simple method, of obtaining the data necessary for calculation.

However, as in every case large working margins have to be allowed for transmitting capacity and efficiency, any scientific exactitude would be superfluous, and practical approximation can always be made which will suffice to enable systematic and reliable working.

I therefore propose to consider some simple methods of finding and using the data applicable to any special case which may be met with in everyday work.

The transmission of power by banding is theoretically the effect of a continuous pull exerted by the friction at the surface of the driving pulley on the band, considered as a partially elastic and semi-flexible coupling. This pull by an inverse interaction again involving the friction at the contact surfaces—*i.e.*, tangential resistance due to normal pressure—exerts a tangential effort at the radius of the driven pulley. The product of this effective pull into the velocity of the point of application considered as a pressure in pounds exerted through a distance in feet per minute gives the value of the transmitted power in foot pounds.

Therefore, $\frac{P\,V}{33{,}000}$ = horse-power. Calling this H we find $P = \frac{33{,}000\,H}{V}$, which is the necessary value of the frictional pull in order to transmit H horse-power at a velocity of pulley rim = V.

Now, the velocity is usually given or directly obtainable, and we need to find the frictional pull. This tangential force depends on the value of the contact pressure between the band and pulley surfaces, or rather the component of that pressure normal to the surfaces, and the "co-efficient of friction"—*f*. This quantity expresses the ratio of the tangential resistance to the normal generating pressure, and is constant for any two given surfaces. The mean value for leather and iron, smooth but dry, is, according to Molesworth, ·54 when *relatively* at rest, but as soon as slip—*i.e.*, relative motion—occurs is reduced to about seven-tenths of the value for repose.

Therefore, putting p for pressure of band on pulley we get $P = \Sigma\,(p)\,f$.

The value of p depends on the weight and tension of band, the pull P transmitted, and on the velocity which, if great, generates centrifugal force, tending to make the band expand radially, and thus reduces the normal pressure. The minimum is attained with a very slack, stationary, and horizontal band, where it approximates to $\frac{w}{2}$, or half the weight of the band. On inclining the system by raising one shaft above the level of the other, the efficiency in this case reduces as the sine of the angle, or with D as the horizontal distance between pulley centres, and L as difference of level, we have due to weight of band

$$p' = \frac{D}{L} \cdot \frac{w}{2} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

acting at an angle with the horizontal $a = \frac{L + \frac{w}{2}}{D}$ approximately.

When any artificial tension is given to the band, the total pressure on the pulleys is the resultant, by the parallelogram of forces, of the tension due to the weight $p_{\prime}$, and this tension 2 T acting along the axis of connection. This tension is divided between the pulleys.

We can therefore formulate

$$p'' = \sqrt{p_{\prime}^2 + T^2 \pm 2\,p'\,T\,.\cos\theta} \quad . \quad . \quad . \quad . \quad (2)$$

where $\theta = 180° - \beta$, the angle between the directions of p' and T being β. If θ be obtuse, the positive, if acute, the negative sign is employed.

As soon as motion is given to one of the pulleys, and there is a tangential strain developed, forming the basis of the transmission of power from one pulley to the other, another component of pressure appears, and increases the total pressure. This is due to the reaction from the rotative couple formed at the driven pulley.

It is quite apparent that the principle of transmission must involve the presence of a greater strain on the driving half of the band than upon the returning half, the difference of tension being, in fact, equal to the effective pull, the product of which into the velocity is equal to the transmitted power.

The various forms of belt dynamometers rely for their action on the measurement of this difference of tension.

The existence of a strain, however, pre-supposes a resistance to force, and we therefore find that the additional tension of a band due to power transmission reacts in producing a greater pressure between band and pulley.

The additional pressure thus attained being equal to the effective pull defined as $\frac{\text{work}}{\text{velocity}}$, and divided between the two pulleys, must be equal to half the difference of tension.

$$S = \frac{33{,}000\,H}{2\,V}, \text{or } \frac{w}{2\,V} \quad . \quad . \quad . \quad . \quad (3)$$

Compounding this with p'' by parallelogram of forces, using equation

$$p''' = \sqrt{p_{\prime\prime}^2 + S^2 \pm 2\,p_{\prime\prime}S\,.\cos\theta'} \quad . \quad . \quad . \quad . \quad (4)$$

θ' as in Eq. (2) being the supplement of the angle between the directions of action of S and p''.

In low speed belting this is at once an approximation of the total normal pressure, and supplies the data satisfying work = W = $\Sigma\,(p)\,.f\,V$.

With high speeds, however, a connection is necessary for the centrifugal force tending to relieve the band pressure on pulley by throwing it off at a tangent, and $w'\,s\,v^2/g$ (where

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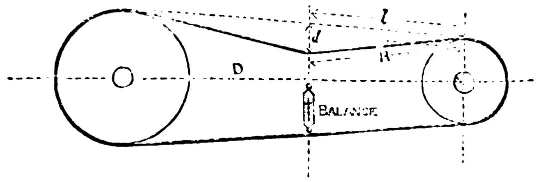
w = heaviness of band, s = section, v = velocity, and g = 32·2 of gravitation accelerative) must be subtracted from the total pressure on pulley.

So much for the theory of the transmitting capacity of a band. Now for practice.

To measure the static tension of any band apply a taut line to the pulley surfaces (see diagram), and then measure the deviation d produced at right angles to the line, by a known force F applied through a spring balance or steelyard, or by a known weight if band is horizontal, in a direction



normal to the taut line, and in the same plane as the loop of the band. Let l = distance from point of application to either pulley, and R the resultant of the combined force along d and band strain along l. The band will tend to set itself on the direction of the resultant, *i.e.*, greatest free force.

Therefore, according to the parallelogram of forces, $R = F.\frac{\sqrt{d^2 + l^2}}{d}$, and the components are as the sides of the triangle $d\,l\,R$, and T is simply $F.\frac{l}{d}$.

When the band is sufficiently slack to "sag" perceptibly, but not excessively, this becomes simply less accurate, as the relation of tension to weight of suspended portion of band is still expressible by $\frac{l}{d}$.

For greater sagging, owing to the deviation being in a catenary curve, or for a nearer approximation, a correction is best made derivable from a summation of the effects of belt weight and the force F, taking the "sag" due to a weight per foot of band w', tension T, and distance apart of pulleys D, as

$$d' = \frac{w'\,D^2}{8\,T}.$$

We can now practically determine the power which a given band can transmit, the general formula becoming H (horse power) $= \frac{f\,V \cdot \Sigma\,(p)}{33,000}$, where $\Sigma\,(p)$ is understood to represent the sum of the static tension T, found, and the dynamic tension S, calculated.

The necessary sectional area of a band to withstand this strain is $s = \frac{P}{p}$, p being the safe working tension of the band. This is for leather, according to Morin, 285lb. per square inch.

We have hitherto left unconsidered the effect of contact area on the tractive power.

It is found in practice that there is an additional adhesion due to a vacuum formed between the band and pulley, and which naturally increases with the arc of contact and width of the former. This is, however, usually left as part of the safe working margin.

It is usual to increase the acting area proportionally to the velocity when dealing with high speeds, and to give the pulley less convexity. A useful approximation for the width of single belting is $W = \frac{1,200 \text{ h.-p.}}{V}$ V in feet per minute; for double belting half this value.

The efficiency of any system of banding is the ratio of the power derivable from the driven pulley to the work of turning at the axis of the driving pulley. The loss is obtained by subtracting the sum of the work of axial friction, and the work necessary to bend and unbend the semi-flexible band. The friction is

$$\phi = N\,2\,\pi f\,r\sqrt{w_2{}^2 + (P + p'')^2 \pm 2\,w_2{}^2\,(P + p'')\cos\theta''},$$

N being number of revolutions; r, radius of spindle; w_2, weight of shaft and pulleys; and θ'' the supplement of angle between the vertical direction of force due to w_2 and the total stress due to band and transmission.

The work of flexure in a band of mean tension, T, and sectional area s, on a pulley of radius r, is $\theta = \frac{T\,s}{b\,r}$, where b is a dimension depending on nature, and for leather = 3·4 inches. (Reuleaux.)

The efficiency is then $\frac{\text{work} - (\phi + \theta)}{\text{work}}$. The total power required to drive a system transmitting a given power is therefore that power multiplied by the sum of such involved terms as the reciprocal of the above efficiency, or

$$H = h\,\Sigma\,2\left(\frac{H}{h}\right),$$

each countershaft and belt decreasing the ultimate yield.

SUBMARINE MINES.

(CONTINUED FROM PAGE 537.)

The Gramme Machine.—This instrument represents the latest and most perfect form of magneto-electric apparatus, for it eliminates the troublesome commutator, and can supply a current as uniform as that of the best voltaic battery. The principles of its construction are equally applicable whether permanent magnets or electro-magnets on the dynamo plan are employed. The former are usually selected for hand machines, and the latter for larger apparatus designed to produce the electric light, or to effect the deposition of metals.

The sample of the hand machine in the School of Submarine Mining at Willets Point is intended for laboratory use. It weighs 67 pounds, and occupies a space of 14 by 13 by 25in. in height.

The permanent magnet is of the Jamin horseshoe type, composed of twenty separate very thin plates, the whole aggregating only ·8in. in thickness, and possessing extraordinary power. Between its poles a ring of soft iron is caused to revolve by a crank so geared as to give 10 revolutions for each turn. A speed of 2,300 revolutions per minute can be given for a short time, and 1,400 are easily maintained.

The ring is wrapped at right angles to its plane by thirty small coils of copper wire, No. 19 B.W.G., connected in series in an unbroken circuit. Each junction between two coils is soldered to a thin strip. These strips are insulated from each other and form the axis of the ring, around which they are secured so as to form an external covering. Two bundles of fine wire are placed, like the springs of a commutator, so as to touch in succession each of these strips as the axis revolves, the points of contact being opposite each other and midway between the poles of the magnet. The bundles are connected by insulated wire with terminal binding posts designed to receive the leading wires.

The theory of the apparatus is simple. The soft iron ring revolves in the magnet field, but *its poles remain* fixed, each adjacent to the pole of the magnet to which it owes its existence. The whole arrangement is, therefore, similar to a series of connected coils through which a bar magnet is passed. By the theory of magnetic induction, two equal and opposing currents are thus generated in the coils of the machine, their points of opposition being where the bundles of wire touch the circuit. Electrically, therefore, the thirty coils are like thirty battery cells coupled in two series of fifteen cells each, with the end cells united in opposition, zinc to zinc and coke to coke. Hence, if the exterior circuit be closed, the bundles of wire simply conduct into it the united current of the two series of cells; if it be open, the two currents neutralise each other.

It has been well established by experiment that the electromotive force of this machine is proportional to the speed of revolution, at least within the limits of practice. A set of measurements was made in March, 1876, to determine the

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numerical values of the constants pertaining to the individual instrument at Willets Point in the general equation:—

$$C = \frac{E}{R' + R''} = \frac{AT}{R' + R''}.$$

In this expression C denotes the current in webers; E, the electromotive force in volts; T, the number of revolutions of the armature per minute (ten times the number of turns of the crank); R′, the internal resistance in ohms (measured between the terminals designed for the leading wires); R″, the resistance in ohms of the external circuit; and A, a constant for the individual instrument.

The quantities R′ and R″ were determined by a standard Wheatstone bridge; the former was ·650 ohm, and the latter (for the circuit used in the measurements) ·163 ohm. It remained to deduce the value of A from measured values of C and E corresponding to a series of values of T. By the method adopted, five operators were required; but since all the variables were measured, the accuracy of the final result admitted of an absolute check.

The external circuit included a Helmholtz-Gaugain galvanometer, of which the weber co-efficient was accurately known, enabling C at any instant to be deduced from the observed deflection. Another circuit led from the terminals of the instrument through a trigger key, a standard half microfarad condenser, and a Thomson galvanometer, so as to admit at any instant of the application of Law's method to the determination of the part of the electromotive force (E′) consumed in overcoming the external resistance. The constant of this galvanometer in volts was derived from two Clark cells freshly set up. Since this second circuit was never closed, it could form no shunt. The crank was turned steadily by a trained assistant at various rates of speed, the number of turns per minute being estimated by the aid of a chronometer.

The mode of operating was to bring the Gaugain galvanometer to a steady deflection by revolving the crank at the proposed speed; and then, at the word, to note the number of turns in ten seconds, record the galvanometer deflection, and determine the corresponding value of E′ by springing the trigger key. The beautiful steadiness of the current generated by the machine enabled good readings to be obtained, notwithstanding the difficulty of securing a uniform rate of revolution by hand. This is apparent from the following table:—

OBSERVATIONS WITH THE GRAMME MACHINE.

No. of Experiment.	Observed.		Measured C			Computed C.	Difference.
	T.	E′	By Gaugain.	$\frac{E'}{\cdot 163}$	Mean.	$C = \frac{\cdot 0045\ T}{\cdot 65 + \cdot 163}$	
		volts.	weber.	weber.	weber.	weber.	weber.
1	540	·61	3·73	3·73	3·73	3·00	+ ·73
2	840	·80	4·76	4·91	4·83	4·65	+ ·18
3	1,050	·90	5·85	5·52	5·69	5·80	− ·11
4	1,260	1·09	6·88	6·69	6·79	6·97	− ·18
5	1,380	1·25	7·21	7·67	7·44	7·63	− ·19
Mean...............			5·69	5·70	5·69	5·61	·28

The value adopted for A, viz., ·0045, was derived from these experiments by a rigid analysis, and the table sufficiently confirms its accuracy. Hence, for the general equation of this individual instrument,

$$C = \frac{\cdot 0045\ T}{\cdot 65 + R''}.$$

Since it is easy to give 1,400 revolutions per minute to the armature, and, by vigorous effort, 2,300 per minute, the electromotive force usually ranges from 6·5 to 11 volts. Experiment with this instrument has shown that ten service platinum fuses united in series can be exploded on short circuit, and that a single fuse can be fired through a resistance of about 24 ohms.

The apparatus can also be used for any purpose where a steady current like a battery is desired, provided only that the crank be turned at a uniform rate. By sending a moderate battery current through the coils, a motion of the crank is produced in the reverse direction to that required to induce the same current by the machine, thus beautifully illustrating the principle of the mutual transformation of electrical and mechanical energy.

(TO BE CONTINUED).

LITERATURE.

Electricity as a Motive Power. By COUNT TH. DU MONCEL and FRANK GERALDY. Translated and edited with additions by C. J. Wharton, with 113 engravings and diagrams. [E. and F. N. Spon, 16, Charing-cross, 1883.]

The characteristic of this work lies in the description of the various motors which have from time to time been brought into public notice. The descriptive portion is, however, prefaced by an introduction of some forty pages dealing principally with theoretical considerations applying to electro-magnets. Although this introduction may not be quite as readable as the descriptive portion, it is, perhaps, more educative, and should be carefully studied. The translator must be rather fearless of criticism to use such language as "All the effects of the electric fluid capable of giving, &c.," when of late years so little countenance has been given to the fluid theory. He sins, however, in good company, if sin it be, since Clerk Maxwell says "Electricity is only one of the factors of energy." The uninitiated reader of this introduction may be considerably surprised to find indications that there is still plenty of experimental work to do in fields that he may suppose have not only been harvested, but gleaned. Thus p. 15 we read: "We are surprised that constructors have not employed such electro-magnets to a greater extent." The electro-magnets referred to are wound with bare copper wire. Again p. 43: "There should evidently be trials made in this direction," that is to counteract the effects of residual magnetism in certain cases. Writing of magnetic inertia it is evident the authors do not think very favourably of the use of the alternate current machines as motors, for we read: "As for the inherent disadvantages of magnetic inertia, the best plan is to diminish the magnetic mass of electro-magnets, to employ tubular electro-magnets and armatures composed of thin plates of iron placed side by side, and to make several slits in the magnetic cores and the surrounding metal surfaces; but the best solution of all is to employ continuous current electro-magnetic motors, as in the reversible machines of Gramme, Siemens, Meritens, and others."

The historical summary which forms Chap. 1 of the work is practically an abstract from *The Electrician* of Sept. 9, 1882. We notice one misprint in this abstract. On p. 49 the volume of the *Mechanics' Magazine* should be XXXII., not XXII. as given, a purely printer's error, but one that may cause trouble to any reader who desires to verify the reference. In the next chapter the historical motors of Jacobi, Davidson, Wheatstone, Elias, Froment, &c., are described, the chapter concluding with the best known of all, that of Pacinotti. The succeeding chapter also continues the description of what may be termed historical motors, for most of them are mere curiosities, although a few, such as Trouvé's, are now used. The first part of the work ends with two short chapters on certain applications of motors, such as the rotation of Geissler tubes, Edison's pen, Paul Lacour's phonic wheel, &c., and on electro-chemical motors. The second part of the work is devoted to the consideration of the more modern and practical machines, most of which have been fully described in our pages. Here, then, we find descriptions of the Gramme, Siemens, Deprez, Baudet, Bürgin, Jabloch-

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koff, Ayrton and Perry, &c., machines, interspersed with theoretical considerations, and descriptions of various experiments upon the transmission of power. The electrical railways of Siemens and Halske, the boat of Trouvé, the experiments of Deprez at Munich, are described, as is the work of others. We are glad to admit that it is greatly due to the energy of M. Marcel Deprez that attention has been so closely directed to electricity as a motive power, but we are emphatically not prepared to admit "that we owe the entire theory as we have given it" to M. Deprez. We shall, however, put aside all controversial questions, and, looking at the work before us as a whole, can safely say that the reader will herein find a clear and concise description of almost every machine worthy of note, with a sufficient amount of elementary theory to make him acquainted with the principles upon which the machines are constructed, and which are to guide inventors in all attempts to use electricity economically as a motive power. The illustrations are numerous, and the translation and annotation well done, though we wish we could induce Mr. Wharton to eliminate I as the symbol for current, and use the symbol generally adopted by English writers, viz., C.

A HISTORY OF ELECTRIC TELEGRAPHY TO THE YEAR 1837.

BY J. J. FAHIE, MEMB. SOC. TEL. ENGS. AND ELECS.*

NOTE.—Being anxious to make his History as complete as possible, the Author will be grateful to his readers for any information, no matter how small, in relation to the subjects treated of in these pages.

CHAPTER IV.—DYNAMIC ELECTRICITY, HISTORY IN RELATION TO TELEGRAPHY.

(CONTINUED FROM PAGE 539).

Fig. 1 represents one of the earliest forms of the pile. It consists of discs of silver, S, zinc, Z, and some bibulous substance soaked in brine, W. The rods R, R, R, are of glass, or baked wood, and with the piece O, which slides freely up and down, serve to keep the discs in position.

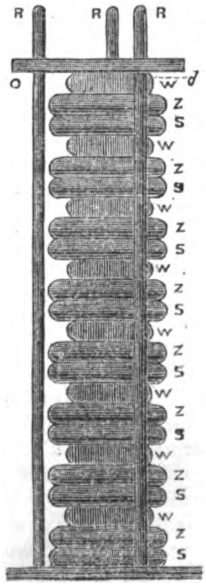

FIG. 1.

The invention of the pile had been scarcely more than hinted at, when the compound nature of water was discovered by its means. The first four pages only of the letter of Volta to Sir Joseph Banks were despatched on the 20th of March, 1800; and as these were not produced in public till the receipt of the remainder, the letter was not read at the Royal Society, or published, until the 26th of June following. This first portion, in which was described, generally, the formation of the pile, was, however, shown in the latter end of April to some scientific men, and, among others, to Sir Anthony (then Mr.) Carlisle, who was engaged at the time in certain physiological inquiries. Mr. W. Nicholson, the conductor of the scientific journal known as *Nicholson's Journal*, and Carlisle constructed a pile of seventeen silver half-crown pieces alternated with equal discs of copper and cloth soaked in a weak solution of common salt, with which, on the 30th of April, they commenced their experiments.

It happened that a drop of water was used to make good the contact of the conducting wire with a plate to which the electricity was to be transmitted; Carlisle observed a disengagement of gas in this water, and Nicholson recognised the odour of hydrogen proceeding from it. In order to observe this effect with more advantage, a small glass tube, open at both ends, was stopped at one end by a cork, and being then filled with water was similarly stopped at the other end. Through both corks pieces of brass wire were inserted, the points of which were adjusted at a distance of an inch and three-quarters asunder in the water. When these wires were put in communication with the opposite ends of the pile, bubbles of gas were evolved from the point of the negative wire, and the end of the positive wire became tarnished. The gas evolved appeared on examination to be hydrogen, and the tarnish was found to proceed from the oxydation of the positive wire. Thus was inaugurated on the 2nd of May, 1800, a new line of research, the limits of which, even now, it is impossible to foresee.*

Nicholson observed that the same process of the decomposition of water was carried on in the body of the pile, as between the two ends of the wire, the side of the zinc next the fluid being covered with oxide in two, or three, days, and the apparatus then ceasing to act. He also observed that the common salt, which had been dissolved in the water, was precipitated, for, gradually, an efflorescence of soda appeared round the margin of the discs.

Nicholson made the further important observation that, by employing discs of considerably more extensive surface, no greater effect was produced in the decomposition of water, or in the strength of the shock; whence he concluded that the repetition of the series is of more consequence to these actions than the enlargement of the surface.†

Cruickshank, of Woolwich, confirmed the observations of Nicholson respecting the appearance of sparks and the decomposition of water. This last phenomenon he varied in different ways. By employing silver terminals, or *electrodes*, and passing the current through water tinged with litmus, he found that the wire connected with the *zinc* end of the pile imparted a red tinge to the fluid contiguous to it; and that, by using water tinged with Brazil wood, the wire connected with the *silver* end of the pile produced a deeper shade of colour in the surrounding fluid; whence it appeared that an acid was formed in the former, and an alkali in the latter, case.

He next tried the effects of the wires on solutions of acetate of lead, sulphate of copper, and nitrate of silver, with the result that, in each case, the metallic base was deposited at the negative, and the acid at the positive pole. In the latter case he observes, "the metal shot into fine needles, like crystals articulated, or jointed, to each other, as in the *Arbor Dianae*." Muriate of ammonia and nitrate of magnesia were next decomposed, the acid, as before, going to the positive, and the alkali to the negative, pole.

These experiments were made as early as June, 1800; and in the September following, Cruickshank published a second memoir, in which he directed his attention to the nature of the gases emitted at the electrodes; to the effects of different kinds of electrodes; and to the influence of the fluid medium. The following are the most important of his conclusions:—

(1). From the wire connected with the silver, or copper, end of the pile, whatever be its composition, if it terminate in water, the gas evolved is, chiefly, hydrogen; if it terminate in a metallic solution, the metal is reduced and is deposited upon the wire.

(2). When the wire connected with the zinc end is composed of a non-oxydable metal, nearly pure oxygen is set free; when of an oxydable metal, it is partly oxydated and partly dissolved, and only a small quantity of oxygen is set free.

(3). When fluids contain no oxygen they appear to be incapable of transmitting the voltaic current; while, on the contrary, it would seem that it may be transmitted by every one which contains this element (Nicholson's *Journal*, IV., pp. 187 and 254).

These views were confirmed by some experiments that were performed, about the same time, by Colonel Haldane. He found that the pile ceased to act when immersed in water, or when placed in the vacuum of an air-pump; that it acted more powerfully in oxygen gas than when confined in an equal bulk of

* The author reserves all rights of translation.

* Nicholson's *Journal of Natural Philosophy*, for 1800, Vol. IV., page 179.

† In some experiments on the combustion of metals, Fourcroy, Thenard, and Vauquelin made the same observation in connection with the trough form of the pile. They found that the energy of the shock and the power of decomposition were not increased by the size of the plates, but by the number of the repetitions; while the same extent of surface, arranged in the form of a few large plates, readily consumed the metallic leaves (*Annales de Chimie*, XXXIX., 103).

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atmospheric air,* and that azote had the same effect as a vacuum. These circumstances led him to conceive that its action depended essentially upon the consumption of oxygen, which it derives from the atmosphere. Haldane also made some experiments on the series of metals which are the best adapted for producing the voltaic effects, and the relative power which they possess in this respect. (Nicholson's *Journal*, IV., pp. 247, 313.)

While these investigations were proceeding, Ritter, afterwards so distinguished for his experimental researches, but then young and unknown, made various experiments at Jena on the effects of the pile; and, apparently without knowing what had been done in England, discovered its property of decomposing water and saline compounds, and of collecting oxygen and the acids at the positive, and hydrogen and the bases at the negative, pole. He also showed that the decomposing power in the case of water could be transmitted through sulphuric acid, the oxygen being evolved from a portion of water on one side of the acid, while the hydrogen was produced from another separate portion on the other side of it. (Nicholson's *Journal*, IV., 511.)

When the chemical powers of the pile became known in England, Sir Humphry (then Mr.) Davy was commencing those labours in chemical science which subsequently surrounded his name with so much lustre, and left traces of his genius in the history of scientific discovery, which must remain as long as the knowledge of the laws of nature is valued by mankind. The circumstance attending the decompositions effected between the poles of the pile which caused the greatest surprise was the production of one element of the compound at one pole, and the other element at the other pole, without any discoverable transfer of either of the disengaged elements between the wires. If the decomposition was conceived to take place at the positive wire, the constituent appearing at the negative wire must be presumed to travel through the fluid in the separated state from the positive to the negative point; and if it was conceived to take place at the negative wire, a similar transfer must be imagined in the opposite direction.

Thus, if water be decomposed, and the decomposition be conceived to take place at the positive wire where the oxygen is visibly evolved, the hydrogen from which that oxygen is separated must be supposed to travel through the water to the negative wire, and only to become visible when it meets the point of that wire; and if, on the other hand, the decomposition be imagined to take place at the negative wire where the hydrogen is visibly evolved, the oxygen must be supposed to pass invisibly through the water to the point of the positive wire, and there become visible. But what appeared still more unaccountable was, that in the experiment of Ritter it would seem that one, or other, of the elements of the water must have passed through the intervening sulphuric acid. So impossible did such an invisible transfer appear to Ritter, that at that time he regarded his experiment as proving that one portion of the water acted on was wholly converted into oxygen, and the other portion into hydrogen.

This point was the first to attract the attention of Davy,† and it occurred to him to try if decomposition could be produced in quantities of water contained in separate vessels united by a conducting substance, placing the positive wire in one vessel and the negative in the other. For this purpose, the positive and negative wires were immersed in two separate glasses of pure water. So long as the glasses remained unconnected, no effect was produced; but when Davy put a finger of the right hand in one glass, and of the left hand in the other, decomposition was immediately manifested. The same experiment was afterwards repeated, making the communication between the two glasses by a chain of three persons. If any substance passed between the wires in these cases, it must have been transmitted through the bodies of the persons forming the line of communication between the glasses.

The use of the living animal body as a line of communication being inconvenient where experiments of long continuance were desired, Davy substituted fresh muscular fibre, the conducting power of which, though inferior to that of the living animal, was sufficient. When the two glasses were connected by this substance, decomposition went on as before, but more slowly.

To ascertain whether metallic communication between the liquid decomposed and the pile was essential, he now placed lines of muscular fibre between the ends of the pile and the glasses of water respectively, and at the same time connected the two glasses with each other by means of a metallic wire. He was surprised to find oxygen evolved in the *negative*, and hydrogen in the *positive*, glass, contrary to what had occurred when the pile was connected with the glasses by wires. In none of these cases did he observe the disengagement of gas, either from the muscular fibre, or from the living hand immersed in the water.

In October, 1800, after many experiments on the chemical effects of the pile, Davy commenced an investigation of the relation which its power had to the chemical action of the liquid conductor on the more oxydable of its metallic elements. He showed that at common temperatures zinc, connected with silver, suffers no oxydation in water which is well purged of air and free from acids; and that, with such water as a liquid conductor, the pile is incapable of evolving any quantity of electricity which can be rendered sensible, either by the shock, or by the decomposition of water; but that, if the water hold in combination oxygen or acid, then oxydation of the zinc takes place, and electricity is sensibly evolved. In fine, he concluded that the power of the pile appeared to be, in great measure, proportional to the power of the liquid between the plates to oxydate the zinc.

To ascertain whether a liquid solution, capable of conducting the electric current between the positive and negative wires of a voltaic pile, but not capable of producing any chemical action on its metallic elements, would, when used between its plates, evolve electricity, Davy constructed a pile in which the liquid was a solution of sulphuret of strontia. When the current from an active pile was transmitted through the liquid, the shock was as sensible as if the communication had been made through water; but, on the other hand, twenty-five pairs of silver and zinc plates, alternated with cloths moistened in the same solution, produced no sensible action, though the moment the sides of the pile were moistened with nitrous acid, the ends gave shocks as powerful as those of a similar pile constructed in the usual manner.

The inventor of the pile maintained that, among the metals, those which held the extreme places in the scale of electromotive power were silver and zinc; and that, consequently, these metals, paired in a pile, would be more powerful, *ceteris paribus*, than any other. But as he also showed that pure charcoal was a good conductor of the electric current, and that the electromotive virtue seemed to depend on the different conducting powers of the metallic elements, it was consistent with analogy that charcoal, combined with another substance of different conducting power, would produce voltaic action. Dr. Wells (*Phil. Trans.* 1795) was the first to demonstrate this by showing that a combination of charcoal and zinc produced sensible convulsions in the frog; and, subsequently, Davy constructed a pile, consisting of a series of eight glasses, with small pieces of well-burned charcoal connected with zinc by pieces of silver wire, using a solution of red sulphate of iron as the liquid conductor. This series gave sensible shocks, and rapidly decomposed water. Compared with an equal and similar series of silver and zinc, its effects were much stronger.

In considering the various arrangements and combinations in which voltaic action had been manifested, Davy observed, as a common character, that, in every case, one of the two metallic elements was oxydated, and the other not. Did the production of the electric current, then, depend merely on the presence of two metallic surfaces, one undergoing oxydation, separated by a conductor of electricity? and, if so, might not a voltaic arrangement be made by one metal only, if its opposite surfaces were placed in contact with two different liquids, one of which would oxydate it, and the other transmit electricity without producing oxydation? To reduce this to the test of experiment with a single metallic plate would have been easy; but in constructing a series, or pile, the two liquids, the oxydating and the non-oxydating, must be in contact, and subject to intermixture. To overcome this difficulty, different expedients were resorted to, with more or less success; but the most convenient and effectual method of attaining the desired end was that suggested to Davy by Count Rumford.

Let an oblong trough be formed as a substitute for the pile; and let grooves be made in it such as to allow of the insertion of a number of plates, by which the trough may be divided into a series of water-tight cells. Let plates of the metal of which the apparatus is to be constructed be made to fit these grooves; and let as many plates of glass, or other non-conducting material, of the same form and magnitude, be provided. Let the metallic plates be inserted in alternate grooves of the trough, and the glass plates in the intermediate grooves, so as to divide the trough into a succession of cells, each having on one side metal, and on the other, glass. Let the alternate cells be filled with the oxydating liquid, and the intermediate cells with the liquid which conducts without oxydating. Let slips of moistened cloth be hung over the edge of each of the glass plates, so that their ends shall dip into the liquids in the adjacent cells. This cloth, or rather the liquid it imbibes, will conduct the electric current from cell to cell, without permitting the intermixture of the liquids.

(TO BE CONTINUED.)

* Biot and Cuvier observed the converse of this. When the pile was enclosed in a limited quantity of air, they found that, after some time, the air was sensibly deoxydated (*Ann. de Chim.* XXXIX., 242).

† In our account of Davy's researches we follow mainly Lardner's "Electricity, Magnetism, and Meteorology," Vol. I., pp. 119-129, which we have carefully collated with Davy's own memoir in the *Phil. Trans.* for 1801.

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THE ELECTRICIAN.

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SURVIVAL OF THE FITTEST.

The friends of electric lighting have had their faith and fortitude taxed to the utmost by the events of the past few months; they have seen one by one a host of companies started with confident expectations, only to disappear by twos and threes into the region of unfulfilled promises. Perhaps these are the unavoidable, the inevitable phenomena attending the beginnings of a new industry, but they are none the less painful to witness, and it requires considerable coolness as well as sound knowledge to contemplate them without dismay. Among those, however, who possess this knowledge there are no signs of faintheartedness, and the coolness which comes of confidence is still prevailing where the mere lay spectator would expect to find nothing but excitement and consternation.

In due time, no doubt, we shall see this element of confidence communicated to the outer world; but for the moment we are bound to admit that it only survives in two quarters, namely, in the hearts of the exceptionally knowing, and in the brains of the excessively ignorant. The scientific world may be taken as the type of the former, the daily newspapers as types of the latter. Science still knows perfectly well what electricity is capable of, and sees with clearness that, helped by a fair amount of money and a reasonable allowance of business capacity, its proffered services will not long be allowed to remain idle. But the scientific world is necessarily a narrow world, and its atmosphere is seldom entered, and seldomer breathed, by the less privileged but far larger world around it. The non-scientific press is its instructor and mentor; and of this it must be said, if it had tried its utmost it could hardly have succeeded better than it has already in discrediting the utterance of those who alone are entitled to speak with authority. The result is that the public in general—those onlookers who are in want of trustworthy information and are neither scientists nor journalists —after passing through various phases of bewilderment and disappointment are now in the final stages of confirmed scepticism.

We must not expect any marked change in this attitude for some time to come, one of the evil consequences of newspaper essays in science being the formation and speedy dissolution of a vast number of speculative, pseudo scientific projects, which otherwise never would have had a chance of being called into being. If the supporters of these enterprises—we will not say the promoters, for they probably knew what they were about—complain of their failure, we can only say that they have nobody but themselves (and the promoters) to blame. The only safe game to play was to avoid the recognised scientific organs, and to appeal to the public press; and this game has been played, promoters and press on the one hand, and shareholders on the other. We will not presume to say who has won; but we may confidently assume the shareholders have not. If they had insisted on submitting the schemes to which they gave their too hasty assistance to competent judges, they at all events would have lost nothing. But they saw—perhaps they preferred to see—their favourite projects puffed in a gushing leader, or in the money article of an irresponsible journal. We do not blame them any more than we blame the pigeon when plucked by the hawk; on the contrary, we are very sorry for them, and we blame a quite different class of people altogether. But we would advise them to be more cautious, and to take better counsel in future.

We have no expectation that our advice will reach the eyes and ears of those whom it most concerns; but the lessons of experience will certainly not be thrown away upon them. These lessons are being taught only too freely just now. Electric lighting news has consisted very largely, sometimes almost exclusively, of winding-up orders, or something even worse. To see the extent of the slaughter one would imagine that none of the combatants have survived. But this is far from being the case. Their name was legion, and not a few of them were veritable giants. These have come out unscathed, and even invigorated by the ordeal. In other words, the process of eliminating the weakest, who in this instance happened to be the most numerous, and selecting the strongest has been going on with much greater rapidity than is common or desirable in the everyday struggle for life. The births were premature and inordinately prolific; the offspring has consequently died off with corresponding celerity, leaving only those who are capable of maintaining a healthy and vigorous life. If the mortality among the small fry is at first alarming, the survival of the bigger fish cannot fail to be reassuring. This is the lesson we may venture to hope the public are even now beginning to learn, and we are confident of its being well understood before many months are over.

There is one other lesson which incidentally has been taught by these recent catastrophes among parents and children of ill-considered electric lighting inventions. We

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mean the ill-advisedness of trusting an invention to the care of the average journalist. Not that we reproach this gifted purveyor of our daily dose of diluted wisdom; he writes his best, and often exceedingly well, on subjects he knows nothing about, and if he misleads, he never fails to entertain us, which after all is his chief function, though he thinks it perhaps something higher. Still, it is not wise of an inventor to pour out his confidences in that quarter. The temptation to assert the "thing which is not" is too great, and the chance of being corrected or intelligently assisted too small to be worth the attendant risks. The moral cowardice which shirks the ordeal of a competent examiner deserves to fail, and sometimes it really does fail, where success might have been possible, for want of more nerve and candour. We are entitled to speak on this point, and we confess we have often hardly known whether to be most astounded or disgusted at the reticence of inventors towards the scientific press. They cannot suppose that they will not be appreciated if they submit something that is good, and we are compelled, therefore, to infer that either they have got something that is bad, something that will only go down with the newspapers, or else something that they are afraid to subject to an impartial scrutiny. Perhaps their experience of shining elsewhere with momentary *éclat*, followed by sudden collapse, may induce them to adopt a bolder, as well as an honester, course in future. Their complete disappearance from the scene of active electric lighting enterprise, however, is not at present to be regretted. With a host of troublesome, frivolous, and unsound competitors cleared out of the way, the remaining workers in the field will have a better chance of fair play, and of convincing the public that, notwithstanding many illusions, the substantial predictions relating to electric lighting are capable of being realised.

CORRESPONDENCE.

OUR TELEPHONE SYSTEM.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Referring to your article on "Our Telephone System" in yours of the 20th instant, and your observations on the paper of Mr. Preece, at the last meeting of the British Association, I trust you will allow me to point out that in many respects you appear to have been wrongly informed as to the actions and proceedings of private telephone companies, and as to the action of the Post Office respecting them, and the facilities given to the public by the systems respectively.

However, to notice your article in its own order. You first allege "that a State-managed system is bound to do its best," and "that private enterprise is bound to do no such thing." The system under private enterprise is bound to meet and anticipate the wants of its customers, and give them every facility for carrying on their business, otherwise they would be unable to make it pay, whilst it is not necessarily the same with the State-managed system, as there are no shareholders to satisfy. There are taxpayers, no doubt, but they are unable to influence the action of the officials in the towns who work the system.

You refer to railways as showing the mischief of private enterprise. I think you could not have given a more unfortunate illustration. For if it had not been for private enterprise, would our railway system have been as far advanced as it is at the present time?

On the contrary, is it not the fact that it is simply because private enterprise has been cramped by the practical monopoly of certain large companies that it has not succeeded in multiplying the lines of railways and railway facilities to a much larger extent than would have been the case had it been free to do so?

As to the beneficial or injurious effect of monopoly, ask any district served by only one railway company what they prefer—ask any district at present served by two or three railway companies whether they would prefer the present state of competition, or would prefer to be handed over to a monopoly; and the answer you would get from the districts would be almost, if not quite, unanimous against monopoly and in favour of competition, and also in favour of every facility being given to private enterprise to serve their wants.

The Post Office may be under the illusion that their system is an ideally perfect one, and that they (the Post Office) have allowed the telephone companies to proceed with the work they had in hand unmolested. Such is not certainly the opinion of the mercantile community, or, I venture to think, of the telephone companies either.

The Post Office have done their best, whether in the north, as at Newcastle, or in the South, as at Bristol and Cardiff, &c., to put every obstacle in the way of telephone companies developing their business and the work they had in hand, and giving telephonic facilities to the public. At Newcastle a private telephone company had an exchange in full working order, and the Post Office took steps to compel its closing, although at the time they did so they had promised to grant a license for such exchange as soon as the necessary documents could be prepared.

This was leaving them unmolested with a vengeance. The Post Office managed to keep that exchange closed for ten months, while in the meantime they were trying to push their own, which, to say the least, was a very shabby proceeding, and very unfair both to the interests of the company and also to the public. As to the Post Office having the best instrument, you add the word "probably," but that is only a slight modification. The fact is they have not the best instrument, and they know it, and that is the reason and the only reason why in granting licenses now they insert a condition—and a most unfair and iniquitous condition it is—that the Post Office shall have a right to use the same instruments that the company licensed use within the district comprised in the license. They not only, however, claim to use but to purchase and even to manufacture instruments for which the owners have had to pay large sums for the patent rights, and this they do without offering any compensation for such patent rights. If their instruments were the best, why should the Post Office be so anxious to obtain others.

As to whose instruments are the best, probably you will admit that the users may be allowed to be the best judges. Take the town of Sunderland, where the Post Office and the company have had a fair start and open competition, and what is the result? It is this, that the company succeed in getting almost the whole of the subscribers on to their system.

As to overhead wires, your article states that the Post Office wires are all laid underground. This is not so. In the provinces they have as many, if not more, overhead wires than the companies, and at the very time your article was being set in type the Postmaster-General was actually taking steps against a London vestry for objecting to his erecting overhead wires.

You can hardly carry on any business without there being something to object to, whether it be smoke, overhead wires, or most inartistic erections. But these things are apt to settle themselves, and probably do so much better without State interference. Of this latter the country is about getting sick. People object to their not being allowed to act, move, or almost think, without the assistance, or supervision, or control, of some central board. Give the public competition, and let them judge which system they prefer, and I am sure that in the future, as in the past, private enterprise will be well to the fore, and that the public will be much better served by their having the choice of systems, either of the Post Office or the telephone companies, whose object is to give their customers the best article they can procure, and the utmost facilities for business in their

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power, knowing that such a course is the only one that will pay them.—Yours, &c., W. H. DIXON.
Sunderland, October 24th, 1883.

DEFECTIVE FIELD MAGNETS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I am making a small dynamo for hand-power, but find it impossible to magnetise the field magnets to any strength. They are made of wrought-iron plate ½in. thick, 13in. long, and 3in. wide (two strips 1½in. wide connected at ends as in ordinary Siemens direct current machine on each side).

One-half of the plate is wound with wire (2¾lb. of No. 16 on each side), and the other half is bent into semi-circular form (as in Siemens machine).

The wire is double cotton covered, and is wound on in five layers. Each layer is insulated with a coat of shellac varnish and a layer of varnished paper.

The resistance is ·5 ohm. I tried it first with three single-fluid bichromate cells, but it would only hold about 1oz. at the covered end of the magnets, the other end being only slightly magnetised. I then tried five Bunsen cells, but with no better result.

The insulation is perfect, the iron is not too hard, and the current (about three amperes) ought to be sufficiently strong, so I am quite at a loss to account for the failure.

I should be much obliged if any reader can suggest the cause.

Is the mass of iron too great for the quantity of wire (5¾lb.) and the current to magnetise properly?—Yours, &c.,
Claremont House, Lee. W. M. H.

THE MUNICH ELECTRICAL EXHIBITION.*

(CONCLUDED FROM PAGE 524.)

As far as the arc lamps tested by the committee were concerned, relative measurements were of less importance than when dealing with incandescent lamps.† The arc lamps in all cases had vertical carbons, and for this reason the emission of light was symmetrical in the horizontal plane. In the vertical plane, taking as unity the light emitted horizontally, the values given in Table I. were obtained at different angles:—

Table I. Light emitted by arc lamps at different angles.

Name of Lamp.	0°	15°	20°	30°	40°	45°	50°	60°
Schuckert	1	2·5	—	4·20	5·0	5·9	4·5	3·2
Schwerd	1	—	—	6·5	—	7·3	7·3	4·1
Crompton	1	3·4	2·5	5·6	4·7	6·8	4·8	4·4
Schæffer	1	—	—	1·2	—	—	1·6	1·6

The curves obtained by means of these figures resemble as a rule the wings of a butterfly. By means of these curves the mean spherical intensity was determined in nearly the same way as for the incandescent lamps.

The co-efficients of reduction for obtaining the mean spherical intensity from the horizontal intensity are as follow:—

Schuckert lamp	1·88
Schwerd lamp	2·51
Crompton lamp	2·18
Schæffer lamp	·93

The absolute measurements were made by noting the electrical and mechanical conditions of the experiment. The results are given in Table II. Such are the principal results of the measurements made by the committee as regards electric lamps. They represent a considerable amount of labour, of which we have only given an imperfect idea, and they are of great importance, particularly those relating to incandescent lamps, which up till now have never been studied on so large a scale.

We must not forget here to congratulate the members of the committee on the results of their labours, and particularly Dr. Voit, who designed the methods of photometrical measurement, edited that part of the report dealing with this matter, and was deputed to study the results obtained in order to draw therefrom the interesting conclusions which we have made known to our readers.

Table II.—Results of the measurements of arc lamps.

Direction of the Rays.	Intensity of light in normal English candles.	Available electrical work in the lamp in volt amperes.	Intensity of light in the lamp per electrical h.p. in candles.	Intensity of light per mechanical h.p. at the machine in candles.
		Schuckert Lamp.		
In a horizontal direction	250	385	477	313
Maximum value (45°) ...	1464	—	—	1513
Mean spherical intensity	470	394	878	579
		Schwerd Lamp		
In a horizontal direction	456	728	461	278
Maximum value (50°) ...	3256	811	2950	1836
Mean spherical intensity	1145	751	1121	788
		Crompton Lamp.		
In a horizontal direction	560	920	448	382
Maximum value (45°) ...	3071	1164	1942	—
Mean spherical intensity	1221	958	939	814
		Schæffer Lamp.		
In a horizontal direction	744	—	—	389
Maximum value (60°) ...	1227	—	—	634
Mean spherical intensity	692	—	—	360

THE PORTRUSH ELECTRIC RAILWAY.

In a note in our issue of the 6th inst. we announced the opening of the Giant's Causeway, Portrush, and Bush Valley Electric Railway, which has been carried out by Mr. W. A. Traill, with the assistance of Mr. E. B. Price, and under the direction of Sir William Siemens. We are now able to give a description of the machinery adopted for utilising the water power of the River Bush to drive the dynamo machines used to generate the necessary current.

At a picturesque spot, known as the Salmon Leap, about three-quarters of a mile from the present terminus of the Giant's Causeway Electrical Railway, the river Bush has a fall of 26ft., a natural advantage as a source of motive power not lost sight of by the promoters of the railway, who have now utilised it for working their dynamo machines. Two turbines, each capable of yielding 50 horse-power at 225 revolutions per minute, are placed in a recess dug out of the solid rock on one bank of the river, and are secured to girders built in concrete and masonry (*vide* Figs. 5 and 6). The water is conducted from its highest point through conduits of considerable length into a wood tank 9ft. wide which bridges the recess, and in which are two sluice valves for opening or closing the inlets to two wrought-iron tubes, each 3ft. 6in. diameter, connecting the tank with the turbines. A framework of wrought-iron joists is placed on the top of the tank, fitted with standards and pedestals for shafting, and is supported at one end by two columns carried down to a girder spanning the walls underneath, whilst the other end is built into a wall. The governors are mounted on a frame and are driven by spur wheels from the upright shafts. An excentric

* From *La Lumière Electrique*, for September 15, 1883.

† For the report of the committee on the incandescent lamps shown see our issue for Oct. 13.

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—not shown on drawing—on the governor spindle works a lever and ratchets on opposite sides of a small wheel, to give motion in opposite directions, according as one ratchet or the other is thrown into gear, to a screw on which a nut can are running at the proper speed both ratchets are thrown out of gear by the governor, and when fast or slow the opening or closing ratchet is slipped into gear by a cam until the inlet opening of turbine is adjusted to correspond.

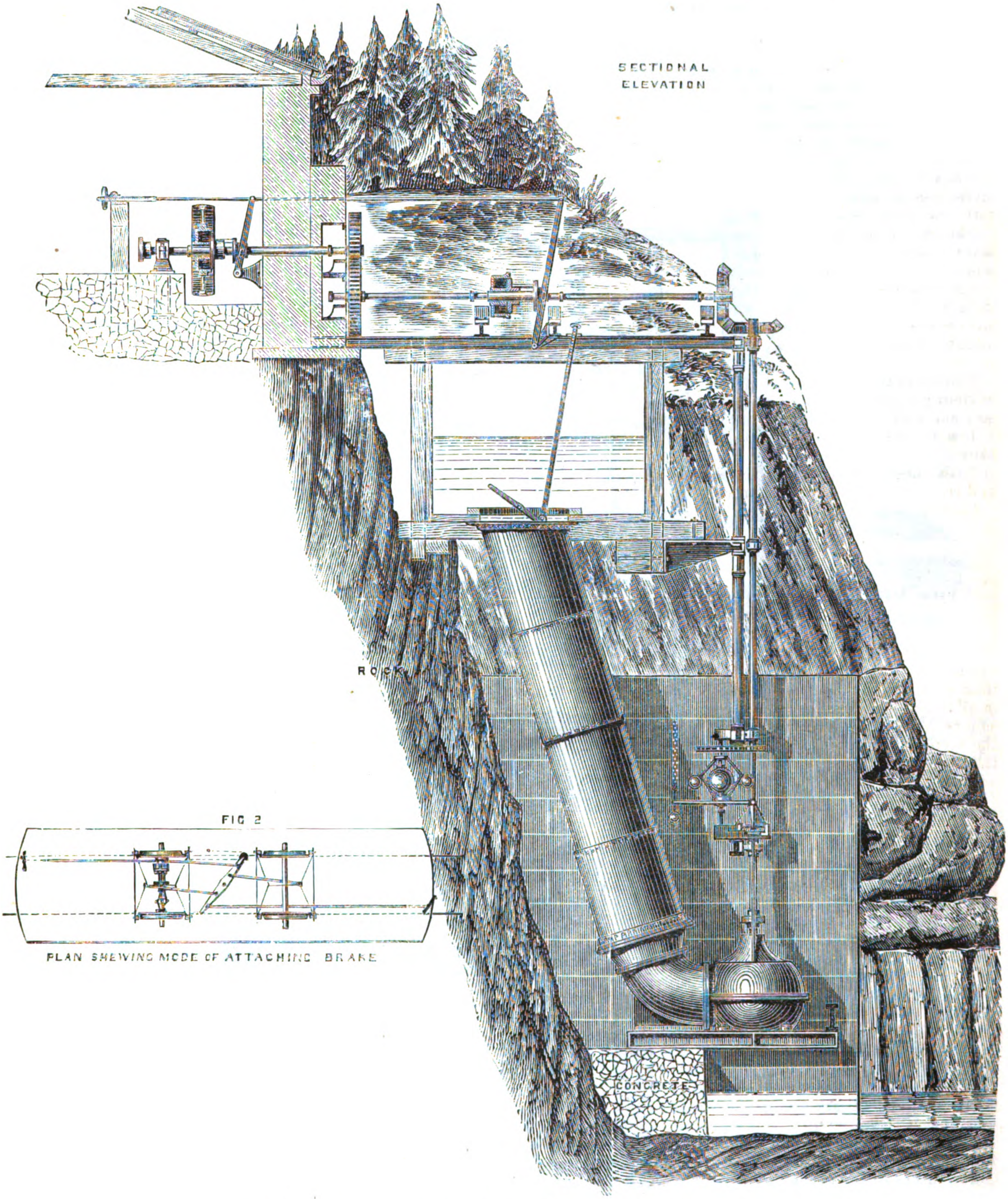

Fig. 5.—Illustration of the Salmon Leap, with Turbines and Machine Room.

travel a sufficient length to move the turbine gate spindle through a quadrant of a circle—the travel of the regulating vanes. A slip motion is attached to the screw at each end to prevent motion beyond fixed limits. When the turbines

Two chains are carried from the machine house to the regulating gear, so that the gates of the turbine may be opened or closed by hand. On the top of the upright shafts are two pairs of bevel wheels to drive two horizontal shafts, on each

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of which is fitted Addyman's friction coupling, whereby both turbines may be left to run idle, or either or both may be put into gear.

A spur wheel on the inner end of each shaft gears into a wheel on another shaft placed immediately above and carried into the machine house, the centres of which wheels would be represented by the three points of a triangle. Thus the turbines may be used singly or together. On the dynamo main driving shaft, again, is placed a friction pulley, which runs or stands according as a wedge is inserted or withdrawn, and the dynamo machine itself may be stopped or started whilst the shaft is in motion, without moving the belt. All the operating levers are brought to one point, and are fixed to a beam in the machine house, duly labelled to show at a glance their different purposes. Only one dynamo machine is worked at present, but it is intended to lengthen

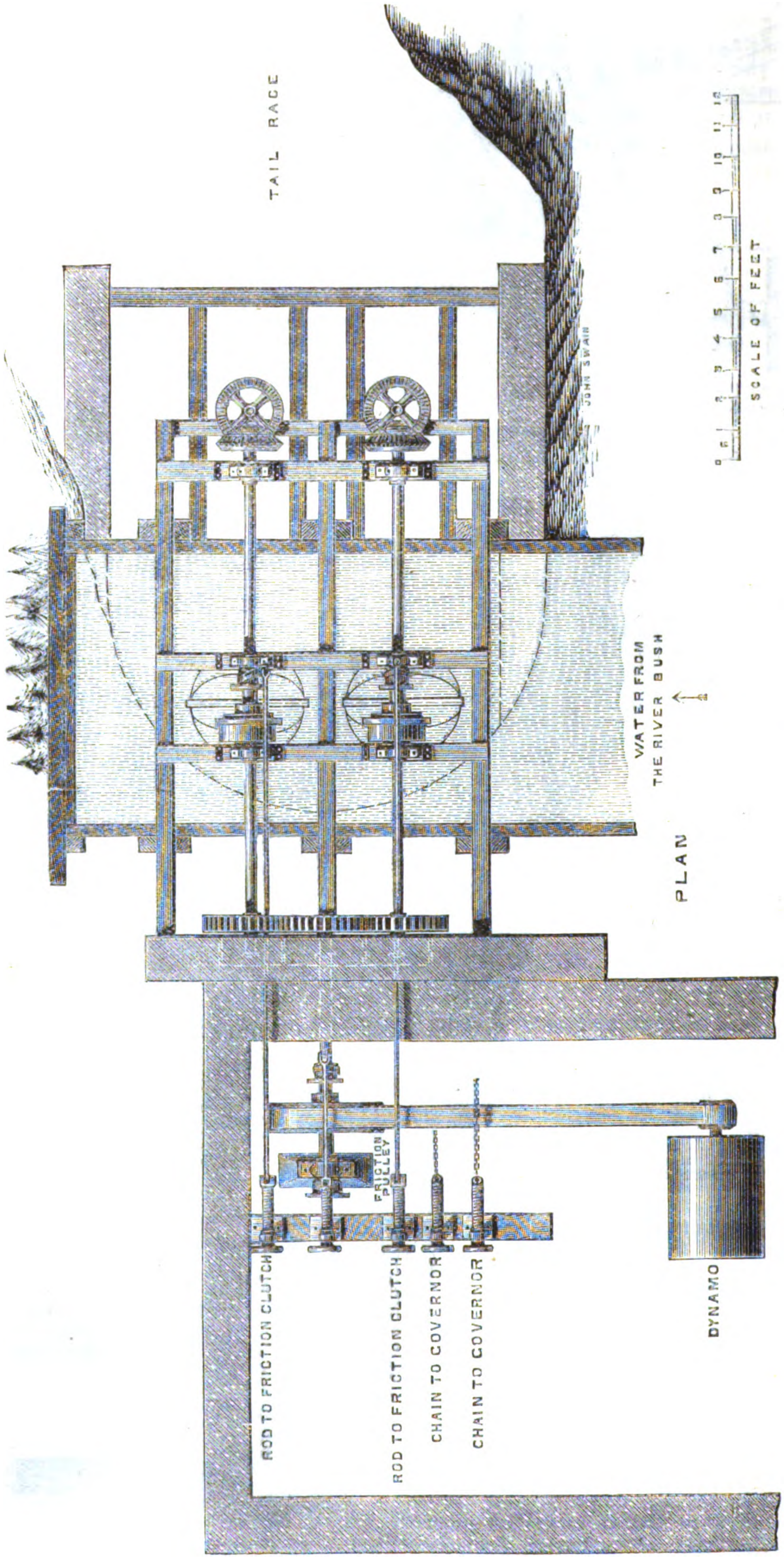

Fig. 6.—Plan of Machine Room, Turbine Arrangement, &c.

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the main shaft in the machine house and work two, preparations for which are already made. The available power—100 h.-p.—is ample for all the requirements of the line, and now that it is in operation will very greatly reduce the working expenses. The whole of the shafting and gearing has been executed by Messrs. J. Bagshaw and Sons, engineers, Batley, under instructions from Mr. W. A. Traill, chief engineer of the tramway company.

The tramcars are fitted with Price's automatic brake, illustrated in Figs. 1 and 2. The brake has been fitted to all the electric cars to meet the requirements of the Board of Trade, and Major-General Hutchinson, at a recent inspection, after trying the car down steep inclines with full power turned on, expressed himself satisfied with its performance, and reported that "an efficient brake had been supplied."

Fig. 1 shows an elevation of a pair of car wheels, with brake apparatus fitted on the axle. A is a drum which runs loose on the axle, and carries Addyman's friction clutch C, one portion being keyed to the axle. When the wedge-pointed rod is pushed in it expands an iron ring, which grips the interior of the drum, thereby causing it to revolve with the axle and to roll up a chain passing through a pulley attached to the end of ordinary hand break cross levers. On

FIG. 1

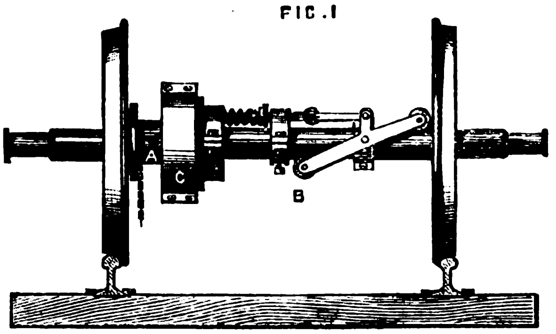
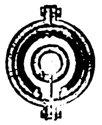
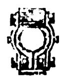


FIG. 3



SECTION THROUGH FRICTION CLUTCH

FIG. 4



END VIEW OF WEIGHTED LEVER

the outer end of axle is fitted a centrifugal governor, B, consisting of a sloping lever with weights at each end. A link connects this lever with the end of wedge rod, and a spiral spring keeps the wedge withdrawn, and the weight lying close to the axle. As soon as the speed of the car exceeds the proper limit, the weights fly outwards, compress the spring, and push in the wedge, which causes the drum to roll up the chain and apply the brakes, with a force proportionate to excess of speed. A pair of spiral springs at each end of the cross lever keeps the brake-box clear of the wheels. It will be seen from the drawings that all parts of the brake are made in halves, so as to enable them to be fitted to axles of existing tramcars.

Fig. 2 (p. 567) shows plan of the ordinary brakes, and mode of attaching the chain to the cross lever. Fig. 3 is a section of Addyman's friction clutch. The brake is set to act at any given speed by simply screwing the lock nuts in either direction, compressing the spring in a greater or less degree. The brakes have been manufactured by Messrs. J. Bagshaw and Sons, Batley, from the designs of Mr. E. B. Price, assistant engineer to the Giant's Causeway Electric Tramway Company. We are indebted to the *Engineer* for most of these details and the illustrations.

New Zealand Telegraphs.—The receipts from telegraphs during the last quarter were £23,480, as compared with £22,446 for the same period of 1882.

THE INTERNATIONAL ELECTRICAL EXHIBITION AT VIENNA.

(FROM OUR SPECIAL CORRESPONDENT.)

VIII.

After the novelty of visiting exhibitions has worn off, there is a feeling of relief to be quit of them. The first idea upon entering a new exhibition is to find the principal stands, and then to make inquiries of friends you are sure to meet if they have seen and can direct you to anything that is new. As a rule, the answer of the men who visit all exhibitions is that there is absolutely nothing new. This answer was received and given upon many occasions at Vienna, but often also with a reservation that the only new thing was the beautifully simple and ingenious electric bell of Abdank. Every one who noticed this apparatus seems to have been struck with its simplicity and utility, and we have no doubt it will be extensively adopted. The apparatus was illustrated and described in *The Electrician* for Sept. 1, so that it is needless to give another description. We have referred to it here because of the unanimity of opinion as to its originality and merits.

It is dangerous to speak of a new design in insulators, for the number of designs is legion; but at any rate a patent is said to have been granted for the design now illustrated, as exhibited by Messrs. Riedinger. The material of which these insulators were made was the ordinary glazed ware well known in telegraphy. The insulator is in two parts (Fig. 1),

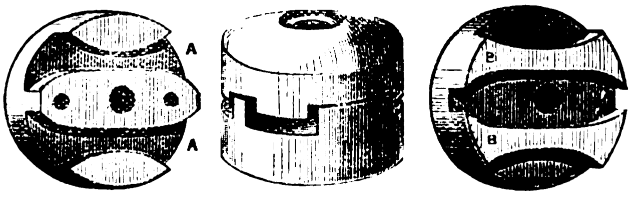


Fig. 1.—Riedinger's Insulator.

the one part having grooves, A, A, to carry the wires, the other having ridges, B, B, fitting into these grooves. The two parts can be screwed together. Our opinion as to the value of such an insulator is that in very dry places it will act as well as any other insulator, and any other insulator as well as it, but in wet, damp, rainy districts it is about as useless a form as can well be devised.

A minor but useful exhibit is that of Hudswell, Clarke, and Co., of Rodger's wrought-iron pulleys. The difference between these pulleys and others of a similar type is that they are made wholly of wrought iron—rim, arms, and boss. Usually the boss is cast. These pulleys, we are told, have been made in large quantities, upwards of 35,000, and can be obtained of any size from 5in. diameter to 24ft. diameter, and any width up to 6ft., to fit any size of shaft. It is reasoned, and with truth, that a pulley wholly of wrought iron is preferable to one partly of cast iron where high speeds are required, as with some dynamos.

Looking after little things has led us again to the exhibit of Schuckert, and although the Sedlaczek and Wikulill lamp, designed to be used as a headlight with locomotives, or for ship use, has been made pretty familiar, in some ways its construction is even now but little known. This is, one may grumble, the fault of illustrated papers. A locomotive with an electric headlight will make a pretty picture, and electros of the picture appear in papers all over the world. There is the picture, but how about the lamp? Ninety per cent. and a few more of the readers imagine that any electric arc lamp may be used, and the letterpress information with the picture does not tell them the contrary. So far, perhaps, the lamp now illustrated has given the best results, but perfection is not yet reached, nor has this lamp come into general use. The principle of the Sedlaczek-Wikulill lamp constructed by

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Schuckert is the employment of two vertical tubes, partly filled with a liquid such as oil or glycerine, communicating with each other. The tubes carry pistons A and B, to which the carbons are rigidly fixed, the + to A the — to B. The piston A is of smaller diameter but heavier than B, so made in fact as to move twice as fast as B, and hence, to keep the arc in one position, A being heavier than B, the latter is raised till the carbons touch. The current is then established, and acts upon an electro-magnetic (M) or centrifugal (F) governor, as shown in Figs. 1 and 2. Suppose the electro magnet M is used. The current causes the core C to be drawn in, and a little piston D in cock E being connected to C is moved, making more room for liquid under piston B, which therefore falls, establishing the arc. The motion of D stops communication between A and B, so that the + carbon is kept stationary. A spring opposes the current, and as the latter becomes weaker pulls ball D, allowing communication between A and B, and the approach of the carbons. The action of the centrifugal governor is easily understood. As the horizontal diagonal of the parallelogram decreases, the piston D is drawn out first, blocking the passage between A and B, then giving greater space to the fluid under B. If the speed increases, which it does as the arc lengthens, and D is pulled further out, a second communication between A and B is opened and regulation of the arc takes place. The second opening is closed as D returns to its normal position. Fig. 4 shows the lamp ready for use.

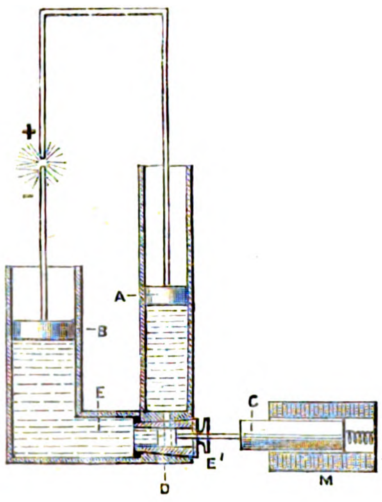

Fig. 2.—Electric Headlight for Locomotive.

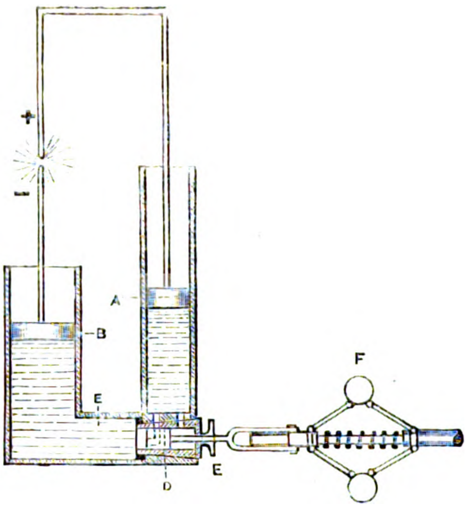

Fig. 3.—Electric Headlight for Locomotive.

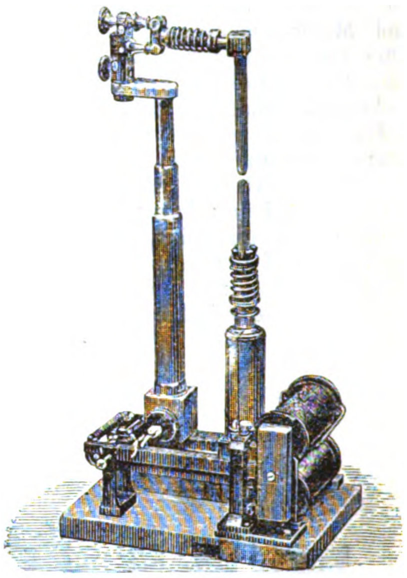

Fig. 4.—Lamp ready for use.

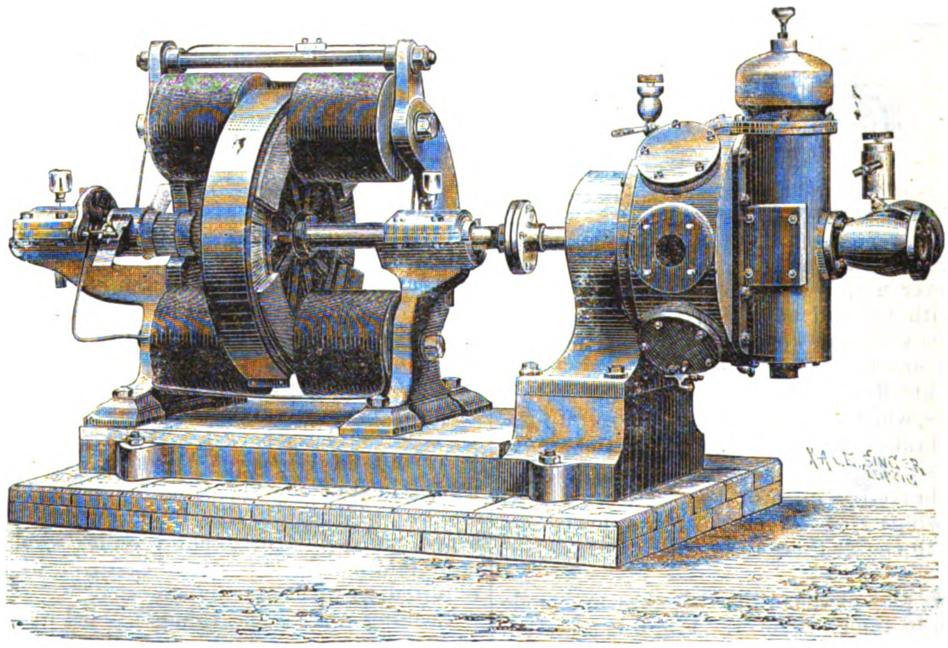

Fig. 5.—Schuckert Machine and Brotherhood Engine, used with Electric Headlight.

Many successful experiments have been made with this lamp as a headlight. The fluid being incompressible the lamp burns well through the shaking and jolting that would inevitably derange any of the ordinary arc lamps. During the experiments on the Crown Prince Rudolf Railway a Schuckert machine, coupled direct to a Brotherhood engine as shown in Fig. 5, was used to generate the current.

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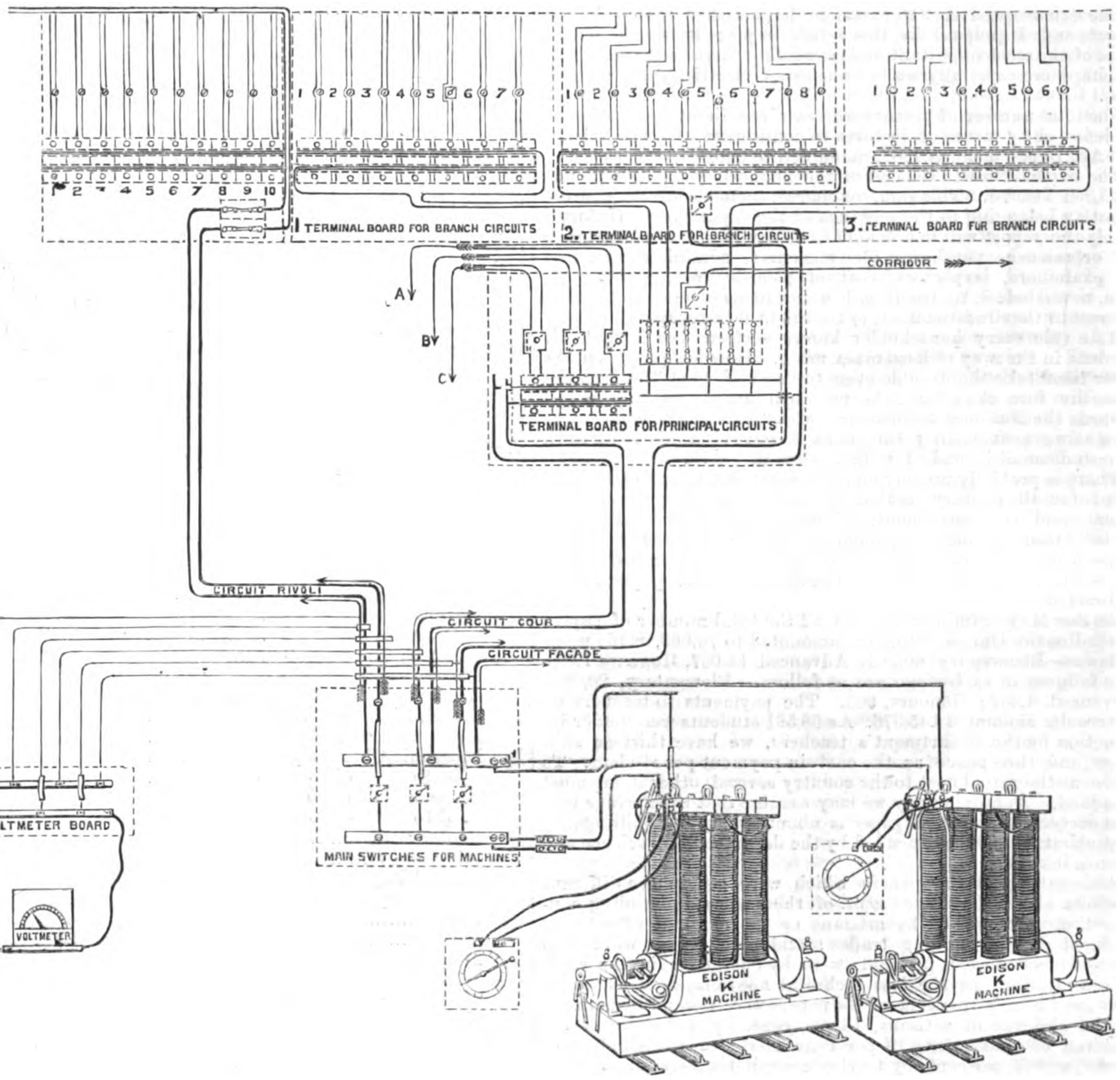
THE NEW TOWN HALL, PARIS.

We give herewith a plan of the switchboard arrangements in this installation of Edison lamps. The number of lamps used is 500, of the 16 candle-power (nominal), the current being supplied by two 250-light machines. The work has been carried out by Mr. G. H. Ward, who has introduced the switchboard arrangement in France. Mr. Ward has had a wide experience in various kinds of electrical work, and hence should thoroughly understand what is required to ensure success. We understand he is now engaged upon an installation of 1,500 lights at Nice. The two dynamos in the installation under notice are driven by two engines of 50 horse-power, from the Société Centrale, Pantin. The connections of the machines through ammeters and voltmeters are shown, to main switchboard to terminal and branch switchboards. Three other switchboards similar to those for branch circuits are arranged, but we have not thought it worth while to reproduce them, as the arrangement can be seen with the diagrams shown. Commencing with the board shown on the right hand marked 3, the circuits of which carry respectively 8, 8, 12, 2, 8, and 9 lamps, and going to the left, the second switchboard controls eight circuits each of one lustre, carrying 16 lamps, the next controls seven circuits, carrying respectively 5, 6, 8, 2, 10, 17 and 15 lamps. Then follow four other switchboards, controlling respectively 10, 10, 12 and 9 circuits, carrying from one to eight lamps. The number of lamps of course varies with the size and position of the room to be lighted. Besides the above the corridor has 28 lamps, the grand hall 32 lamps, and so on—making the total number of lamps as we say 500. It will be seen that the lamps in any room can be controlled from a central position.



Plan of Circuits in the new Town Hall, Paris, as designed by Mr. G. H. Ward, of the Société Electrique Edison.

Magnetic Susceptibility of Soft Iron.—Errata.—In Professor Ewing's paper under this title, printed in our last issue, the following corrections should be made:—For "I. A. Ewing," read "J. A. Ewing." On page 546, line 17 from bottom of column 1, for "K" read "κ"; on page 546, line 12 from bottom of column 1, for "as rapidly" read "so rapidly."

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SCIENTIFIC INSTRUCTION, UNDER THE SCIENCE AND ART DEPARTMENT.

BY THOMAS T. P. BRUCE WARREN.

With the return of the autumn we enter upon what may be called the educational season. The long evenings, and the impossibility of finding suitable outdoor amusements or recreation render this part of the year eminently appropriate for study. During the present month there will be classes for scientific study opened in almost every town of importance in the United Kingdom, and for some time to come teachers and pupils will be actively engaged in the struggle for fame. Few people, including even that section of the British public which prides itself on its reading appetite, have any idea of the extensive system of teaching and educational work put into operation by each returning October.

The Science and Art Department have issued their thirtieth report, and I propose in this article to place before the reader some of the most important and interesting facts contained in it, bearing more especially on the science of electricity and magnetism.

The total number of persons who received direct instruction as students, or by means of lectures in connection with the Science and Art Department in 1882, amounted to 986,085.

The expenditure to the end of the financial year 1882-83 was £345,363 14s. 7d. This sum, of course, includes all the sources of outlay belonging to the province of the department. Unfortunately the report will not enable us to say how much belongs to art or science, purchases for museums, administration, fees for examiners, inspectors, cost of printing, &c., but we are able, nevertheless, to disentangle a few items of more immediate interest to the educationalist, or the scientific ratepayer.

As a rule every householder knows perfectly well what his burdens in the way of local taxes mean. How few people on the other hand take the trouble even to think of what the imperial taxes are for. As a rule, the principal interest we have or feel towards the National Exchequer is to settle with the collector as soon as we conveniently can, so as to get rid of his visits until a fresh demand is made for the new taxes.

There is probably no portion of our imperial taxes so profitably spent for the country as that which is expended through the Science and Art Department. From a careful study of the reports issued by the department, we can learn not only the advancement which is taking place in science instruction, but we can see to what particular branches of science the popular taste is directed.

At the May examinations in 1882 the total number of papers worked in the United Kingdom amounted to 76,063, made up as follows:—Elementary 60,504, Advanced 14,067, Honours 1,492. The failures in each stage are as follow:—Elementary, 20,000; Advanced, 4,357; Honours, 965. The payments to teachers on the results amounted £45,376. As 68,581 students were under instruction by the department's teachers, we have thirteen shillings and threepence as the cost in payment per student. To arrive at the actual cost to the country several other items must be added. Approximately we may assume that the average cost of a successfully worked paper is about twenty-five shillings, so that about £80,000 is expended by the department on science and science instruction.

An analysis of the papers which were set in the different subjects shows that 77 per cent. of the papers in building construction were worked by artisans or the children of artisans engaged in the building trades; and of the papers worked on applied mechanics 80 per cent. were by operatives in the engineering trades. In the less technical subjects, such as sound, light, and heat, 27 per cent. of the papers were worked by artisans or the children of artisans, 18 per cent. by tradesmen or the children of tradesmen, 19 per cent. clerks or the children of clerks, and 36 per cent. by teachers, pupil teachers, or students at school. In magnetism and electricity the percentages in these several categories were respectively 30, 22, 18, and 30.

The total amount paid by the students themselves amounted to £13,140 13s. 17½d. The average sum paid per student is in England 4s. 6d., Scotland 7s. 10d., Wales 4s., and Ireland 1s. 9d. These figures unmistakably prove that Scotchmen have the highest appreciation of the importance of scientific education.

Magnetism and electricity appears to be the science most extensively studied in these schools or classes. The following summary gives the number of classes and students in each subject for 1882 under the Science and Art Department:—The total number of schools was 1,522. In electricity and magnetism the number of students who presented themselves for examination in 1883 is 11,310, showing the enormous decrease of 4,513. Of this number only 116 obtain first-class advance certificates, 828 obtain second class, and 665 fail. In the elementary stage 1,708 pass first class, 5,763 second class, and 2,163 fail. In honours there are 56 failures, whilst only two obtain first-class, and nine second-class certificates.

The report by Professors Guthrie and Foster, the examiners in magnetism and electricity, which was distributed to the teachers in the earlier part of 1882 will perhaps be read with much interest by those who contemplate sitting for these examinations:—

"The answering in the elementary stage shows some improvement, especially in regard to magnetism and frictional electricity. In voltaic electricity the answering was less satisfactory.

"It is difficult to feel sure how far the comparatively unsatisfactory answering in voltaic electricity may arise from the fact that the questions on this part of the subject are placed at the end of the paper; so that, as a rule, candidates do not come to them until a good deal of time and energy have been expended on the earlier parts of the paper.

"It frequently happens that answers contain statements correct as to matters of fact, but which have little direct bearing on the question set. This appears to arise from the candidate catching at some word or phrase in the question which suggests something he has learnt, but which he is not asked for.

"The answering in the advanced stage is less satisfactory than that in the elementary stage. As usual, a good many who have attempted the advanced are obviously insufficiently prepared even for the elementary. Attention is called in the syllabus to the necessity of candidates at the advanced stage being prepared to answer questions involving quantitative relations. The questions intended to test this kind of knowledge have been on the whole very imperfectly answered.

"It ought to be understood that a satisfactory knowledge of the subjects embraced in this examination (beyond the elementary stage) must be based upon clear conception of the fundamental ideas of mechanics, inasmuch as all electrical and magnetic measurements are ultimately measurements of mechanical effects.

"In regard to the Honours paper, very few who took this paper appeared to have any idea of the kind and amount of knowledge expected at this stage. Their answers were, as a rule, very deficient in precision, and gave little evidence of accurate practical knowledge."

Subjects.	No. of Classes.	No. of Students.
Practical Geometry	337	7625
Machine Drawing	439	9471
Building Construction	388	6246
Naval Architecture	23	475
Mathematics, Stage 1	629	15965
Ditto Stage 2	20	294
Ditto Stage 3	11	241
Theoretical Mechanics	126	2768
Applied ditto	162	3161
Sound, Light, and Heat	273	6655
Magnetism and Electricity	554	15823
Inorganic Chemistry (Theory)	353	10545
Ditto ditto (Practical)	155	4885
Organic ditto (Theory)	45	747
Ditto ditto (Practical)	46	1225
Geology	118	1862
Mineralogy	15	182
Animal Physiology	397	8419
Elementary Botany	143	3042
Biology	24	365
Mining	21	482
Metallurgy (Theory)	22	391
Ditto (Practical)	7	71
Navigation	33	658
Nautical Astronomy	7	279
Steam	112	2562
Physiography	353	7036
Agriculture	358	7007

THE TRANSMISSION OF ENERGY.*

BY PROF. OSBORNE REYNOLDS, M.A., F.R.S.

Lecture I.—Monday, April 23rd, 1883.

Some few days ago, during a conversation with a friend, I remarked that I was going to give some lectures at the Society of Arts upon the transmission of energy, whereupon my friend inquired, "Is that the transmission of energy by electricity?" To this I replied, "No." The fact is that we have heard so much about electricity that I began to think it was time to recall

* Cantor Lectures, reprinted from the *Journal of the Society of Arts.*

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attention to the fact that there are other means of performing mechanical operations.

I am not sure whether, during the various lectures which have been given in this room on electricity, the actual term, transmission of energy, has been used. But whether it has or not, some of the leading ideas connected with it have been before you.

I think it may be said that the great interest which the public has manifested in the recent advance in the arts relating to electricity has arisen, in a large measure, from the cry of joy with which Faure's battery was received, a cry which said, in so many words, "Here we have at last a means of utilising our waterfalls and natural sources of power in a way that may relieve us of all the anxiety about our coal fields." To those who had studied the subject, it was evident at the time that this cry was premature. And to some of us, at all events, it seems to be a mistake to encourage false hopes, or, rather, knowingly to base hopes on a false foundation, to hold out as a means of replacing our coal what was, in all probability, only another means of increasing its rate of consumption, for every step in art which facilitates the application of power must increase the demand on the acting sources.

But this is not all; the exaggerated claim set up for electricity, diverted, for a time at all events, attention from the true claim, which would have been sufficient in itself had it not thus been put out of sight. It is not our object at present to save our coal, but to turn it to the best advantage to get the greatest result we can, and if Faure's battery or any subsequent advance in this direction conduces to this, it is no small matter. Now, during the last ten or fifteen years, an entirely new aspect has been given to mechanics by the general recognition of the physical entity which we call energy, in different forms.

We recognise the one thing under different forms in the raised hammer, the bent spring, the compressed air, the moving shot, the charged jar, the hot water in the boiler, and the separate existence of coal, corn, or metals, and oxygen. We see in the revolution of the shafts and the travel of belts in our mills, the passage of water, steam, and air along pipes, the conveyance of coal, corn, and metals, and the electric currents, the transmission of this same thing—energy—from one place to another; and in all mechanical actions we perceive but the change of form of the same thing.

Taking this general or energy point of view, we may get rid of all the complications arising from special purpose, and recognise nothing but the form of energy in its source, the distance it has to be transmitted, and the special form that must be given to it for its application. And this view, although not the best in which to study the special purpose of mechanics or contrivances, is of great importance, inasmuch as it has revealed many general laws, and many fundamental limits to the possibilities of extension in certain directions.

My object in these lectures is to direct your attention to some of the leading mechanical facts and limits revealed by this view.

There is one general remark I would wish to make, by way of caution. I hope nothing I may say will be interpreted by any of my hearers into a prediction as to what may happen in the future. I have to deal with facts, and I shall try to deal with nothing but facts. Many of these facts, or the conclusions to be immediately drawn from them, may appear to bear on the possibilities—or, rather, the impossibilities—of art. But in the Society of Arts I need not point out that art knows no limit; where one is found to be closed, it is the function of art to find another. Science teaches us the results that will follow from a known condition of things; but there is always the unknown condition, the future effect of which no science can predict. You must have heard of the statement in 1837, that a steam voyage across the Atlantic was a physical impossibility, which was said to have been made by Dr. Lardner. What Dr. Lardner really stated, according to his own showing, was that such a voyage exceeded the then present limits of steam power. In this he was within the mark, as any one would be if he were to say now that conversation between England and America exceeded the limit of the power of the telephone. But to use such an argument against a proposed enterprise is to ignore the development of art to which such an enterprise may lead.

I wish to do nothing of this kind, and if, in following my subject, I have to point out circumstances which limit the possibilities of present art, and even seek to define the limits thus imposed, it is in the hope of concentrating the efforts of art into what may be possible directions, by pointing out the whereabouts of such barriers as science shows to be impassable.

Although the terms energy and power are in continual, we might almost say familar, use, such use is seldom in strict accordance with their scientific meaning. In many ways the conception of energy has been rendered popular, but a clear idea of the relation of energy to power is difficult. This arises from the extreme generality of the terms; in any particular case the distinction is easy. I was going to say that it is easiest to express this distinction by an analogy, but, as a matter of fact, everything that seems analogous is really an instance of energy. Power may be considered to be directed energy; and we may liken many forms of energy to an excited mob, while the directed forms are likened to a disciplined army. Energy in the form of heat is in the mob form; while energy in the form of a bent spring, or a raised weight, matter moving in one direction, or of electricity, is in the army form. In the one case we can bring the whole effect to bear in any direction, while in the other case we can only bring a certain portion to bear, depending on its concentration. Out of energy in the mob form we may extract a certain portion, depending on its intensity and surrounding circumstances, and it is only this portion which is available for mechanical operations.

Now, energy in what we may call its natural sources has both these forms. All heat is in the mob form, hence all the energy of chemical separation, which can only be developed by combustion, is in the mob form; and this includes the energy stored in the medium of coal. The combustion of 1lb. of coal yields from ten to twelve million foot-pounds of energy in the mob form of heat; under no circumstances existing at present can all this be directed, nor have we a right, as is often done, to call this the power of coal. What the exact possible power is we do not know, but probably about four-fifths of this, that is to say, from eight to ten million foot-pounds of energy per pound of coal is the extreme limit it can yield under the present conditions of temperature at the earth's surface. But before this energy becomes power, it must be directed. This direction is at present performed by the steam-engine, which is the best instrument art has yet devised, but the efficiency of which is limited by the fact that before the very intense mob energy of the fire is at all directed, it has to be allowed to pass into the less intense mob energy of hot water or steam. The relative intensity of these energies are something like twenty-five to nine. The very first operation of the steam engine is to diminish the directable portion of the energy of the pound of coal from nine millions to three millions. In addition to this there are necessary wastes of directable energy, and a considerable expenditure of already directed energy in the necessary mechanical operations. The result is that, as the limit, in the very highest class engines the pound of coal yields about one-and-a-half millions of foot-pounds; in what are called "first-class engines," such as the compound engines on steamboats, the pound of coal yields one million; and in the majority of engines about five or six hundred thousand foot-pounds. These quantities have been largely increased during the last few years; as far as science can predict they are open to a further increase. In the steam engine art is limited to its three million foot-pounds per pound of coal; but gas engines have already made a new departure, and there seems no reason why art should stop short of a large portion of the nine millions.

Other important natural sources of mechanical powers are energy in an already directed or army form, wind and water power. Here the power needs no development, but merely transmission and adaptation, and hence it has one important advantage over the energy of chemical separation. But there appears to be what are greater drawbacks—in the irregularity of these forces as regards time, and the distribution as regards space. These have both been, and are, good servants to man.

The application of the power of the wind to the propulsion of ships, has, doubtless, influenced the economy of the world more than any other mechanical feat; and, not very long ago, water-power played no relatively unimportant part of the work of the world. But it would seem that both these have had their day, and are now relegated to work of a secondary kind, not necessarily so. Some further development of art might bring them to a foremost place again, by developing their use to a hitherto unprecedented extent. Hitherto both wind and water have only had a local application—that is to say, they were used where and when they were wanted. Wind was only used in the sailing of ships on voyages, and for mills, distributed so as to be within range of such corn as was too far from water; while water-power, though very valuable to a certain limited extent, when near habitable country, was otherwise allowed to run to waste; and these wastes included by far the larger sources of this power—the larger rivers and waterfalls, the tidal estuaries, and last, but not least, the waves of the sea, a source which has never been utilised for good. A modern idea is that it needs nothing but a possible development of art to render these larger sources not only available for power in their immediate neighbourhood, but available to supply power wherever it is wanted, and so displace the coal, or replace the power as coal becomes exhausted. The desirability of such a result fully explains the entertainment of the pleasant idea; but, unfortunately, when we come to look closer into the question, the probability of its accomplishment diminishes rapidly. Many of the considerations of which I shall

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have to speak bear directly on this question; so that I shall now defer its further consideration, merely pointing out that, to accomplish this result, the power must not only be extracted from the water on the spot and at the same time, but it must be transmitted over hundreds or thousands of miles, and must be stored till it is wanted.

It may well be thought that energy in a directed form, or in the army form, may be better transmitted than in the undirected or mob form. As a matter of fact, however, energy has never been and never can be transmitted as mechanical power in large quantities over more than trifling distances, say, as a limit, twenty or thirty miles. I say never can because such transmission depends on the strength of material; and unless there is some other material on the earth of which we know nothing, we know the limit of this. This is a part of my subject into which I shall enter more closely in my second and third lectures.

In depreciating the idea that wind and water will ever largely supply the place of coal, I do not for a moment wish it to be thought that I take a gloomy view of the mechanical future of the earth. This, I believe, admits of immense development, and will not for long depend, as it does at present, on the adjacency of coal fields. This will be explained as I proceed.

It must not be forgotten that, after all, the most important source of energy is not coal, but corn and vegetable matter. The power developed in the labour of animals exceeds the power derived from all other sources, including coal, in the ratio of, probably, 20 or 30 to 1; so that, after all, if we could find the means of employing such power for the purposes for which coal is specially employed—such as driving our ships and working our locomotives—an increase of 10 per cent. in the agricultural yield of the earth would supply the place of all the coal burnt in engines. The energy which may be derived from the oxidisation of corn has as yet only been artificially developed in the form of heat, and this may be the only possible way; but physiology has not yet advanced to the point of explaining the physical process of the development of energy consequent on the oxidisation of the blood; and it is at all events an open question whether the energy of corn may not be really a form of directed energy, in which case corn would yield six or eight times as much energy as coal does at present, consumed in our engines. As consumed in animals, it yields a larger proportion of energy—two or three times as much, and may be more—whereas, by burning it in steam-engines, we cannot get half as much. Should we find an artificial means of developing anything like the full directable power of corn—a problem which has not yet been attempted—coal would no longer be necessary for power. I do not mention this as a prediction, but as showing that there are, besides wind and water, other, and as yet untried, directions from which mechanical energy may be derived in the future.

Electricity is not a natural source of energy, for the simple reason that the metals have mostly been burnt or oxidised during the past history of the earth. But still it is important, at this stage of my lecture, to point out that the energy consequent on the separate existence of metals and oxygen can be developed without combustion, in a totally directed form, *i.e.*, totally available for power.

There are many peculiarities which distinguish the group of elementary substances we call metals, but there is no more distinctive feature than this. This is not a primary source of power, but, as it at present appears, it promises to become the most important secondary source. We cannot find metals existing in a separate form but by the use of power; where and when it exists, we can separate them from the salts, and so store the energy in a form completely available for power. The economical questions relating to such storage of energy will be considered in their place later in the course.

It is not, however, only as affecting storage of power that electricity demands our attention, it also affords a means of transmitting power, which has long held an important place in art, and to which all eyes have been recently turned in expectation of something new and startling.

Before considering the developments of art, and the circumstances on which their further development depend, I shall turn, for a moment, to the processes of nature. The mechanics of the universe, no less than those relating to human art, depend on the transmission of energy. In nature, energy is transmitted in all its form and under all circumstances, both those which we can imitate in art, and those we cannot.

The most important point with regard to the artificial transmission of energy is the proportion of power spent in effecting the transmission, and the circumstances on which this proportionate loss depends. Is such loss universal? So far as we know, it is attendant in a greater or less degree on all artificial means of transmission, and on all transmissions effected by nature on the surface of the earth. If it were not, this earth would be no place to live upon. No motion would ever cease. As it is, the winds and waters are rapidly brought to rest by the friction which they encounter. Currents of wind and currents of water form the principal means by which energy is transmitted over the surface of the earth. But there are other means which experience less resistance. Oscillatory waves, those of sound, are a very efficient means of transmitting energy. Sounds are not transmitted to an unlimited distance, chiefly because, by the spreading of the wave, the sound becomes weaker and weaker as it proceeds. It is also destroyed by the friction of the solid surface of the earth. Hence the sounds which reach us from bodies high up, as the explosion of a meteor, are heard much further than such sounds made at the surface of the earth, although there are two records of artillery having been heard two hundred miles. Owing to such incidental destruction of sound we cannot say from experience that sound waves in foul air are destroyed, but from the physical properties of gases we know they are.

Waves on the sea are another very efficient means of transmitting power, a means which may be called nature's mill. The waves which take up the energy or power from the wind in mid ocean travel onwards, carrying this energy, and experience such slight resistance that they will, after travelling hundreds or thousands of miles, destroy the shores on which they expend the last of their energy. If we could find a means of utilising the energy of waves, we should not only save our coal, but also save our country from the waves; still, water waves experience resistance which we can better estimate theoretically than practically.

These are the principal ways in which energy is transmitted from one part of the earth to another. There are others, such as earthquakes, but they all show the same thing, that power is spent in the transmission of energy.

If we look away into interstellar space, the case is altered. Here we see two ways in which energy is transmitted—heat, or light, and the motion of the heavenly bodies. In neither of these can we see any direct evidence of resistance or loss of power; and, as judged by any terrestrial measure, there certainly is none. The distance at which we see stars is a sufficient proof of the freedom with which the wave of light travels; while the regularity of the motion of the planetary bodies shows that they encounter no sensible resistance. Yet, although not directly perceivable, there are circumstances that strongly suggest that in both these forms transmission of energy is resisted. If space is unlimited, and there are stars throughout it, why do not we see them at greater distances than we do? Under these circumstances, there could be no spot in the heavens at which at a sufficiently great distance there was not a star, so that, if the light were not stopped, the whole heavens would be one fiery envelope as bright as the sun. This is a question which philosophers have not decided. But one, and the favourite way out of the difficulty, is to suppose that the light does encounter resistance, even in interstellar space. This is a subject on which your Chairman of Council has boldly launched; and whether his hypothesis be right or wrong, it has brought to the front a very interesting subject.

With regard to the resistance encountered by the planetary bodies, our evidence is even slighter. A few domesticated comets seem to diminish their speed, and it is not so long since we were all on the *qui vive* by the promise of the spectacle of an old friend, who seemed to have come earlier than he was expected on purpose to verify a prediction of plunging into the sun, but instead of doing so he passed away and was pronounced a stranger, to the joy of the nervous but somewhat to the discomfiture of astronomers.

The energy which we derive from the sun comes to us, in the form of sunshine, in a highly directed but extremely scattered form, being uniformly distributed all over the illuminated disc of the earth. It reaches the outer atmosphere nearly in the same condition as it left the sun, having traversed ninety odd millions of miles without any sensible expenditure of power. In the twenty or thirty miles of the lower atmosphere, however, it encounters very great, but variable, resistance. Sometimes half of it, or three-quarters of it, may reach the earth's surface. This is rare in our country, and on the average not more than a very small fraction ever reaches the surface.

When the sun does shine, the sunshine is a form of energy which may be, and is, very largely directed so as to yield power. Any such direction which may be accomplished by human art is undertaken at an enormous disadvantage, on account of the scattered manner in which the energy reaches us. The sunshine must be collected before we can make any mechanical use of it.

In the abstract, there are two methods. The one would be to accumulate the energy of sunshine on a given place, over a long time. This is nature's method. The energy on each portion of the earth's surface, during days, weeks, the whole year, or many years, is accumulated by the growth of vegetables. Corresponding to this, however, art has as yet developed no means whatever.

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If we do not use the sunshine as it falls, energy is lost for all mechanical purposes. I say if we do not, not that we do use it, but because we can, and have done so in a small way. By means of a lens, or reflectors, the sunshine which falls on a certain place may be concentrated on to a smaller space, and so be sufficient to perform some mechanical operation. In this way, small vapour engines have been worked by sunshine. But the cost of the apparatus necessary for such concentration is out of all proportion to the result accomplished, and shows the art difficulties must be got over by a new departure. There is the further consideration that sunshine on land is too valuable for the maintenance of vital energy to allow of its being devoted to mechanical purposes.

As regards the perfectness of nature's method, so far as I know, no attempts have even been made to test this. It is probably very wasteful, as are all nature's methods, but it is effective. In the first instance, the energy of sunshine is stored on the spot where it falls, in the tissues, but chiefly in the sap of the grass and vegetation. If this is not removed, a large portion of the energy of the year's growth, that which is in the sap, is stored in the seed, and the rest, although apparently again scattered on the decay of the tissues, is to some extent preserved in the ground, and either forwards the next year's crop, or takes the permanent form of peat; and our coal fields are but evidence of the way in which the directable energy of sunshine has been stored under circumstances where there was no immediate purpose for which to apply it. Under present circumstances, however, this energy is almost everywhere too valuable to admit of secular storage.

It is either removed directly by nature's method, the teeth of animals, or allowed to accumulate for a longer period, and then removed by human industry. The further aggregation of this energy involves the transmission of energy in a mechanical sense, and hence involves the expenditure of power. Nature works by means of directly converting this energy into power. The plant accumulates the energy of sunshine, the animal collects and appropriates this energy. This collection is accomplished by the expenditure of power, which means a redistribution of that portion of the energy which is capable of direction. The scheme of nature, therefore, is a cycle. The vegetation accumulates the energy, as far as time is concerned, leaving it in a scattered form, requiring power to collect it; this power is in the grass, and only wants direction; this it receives in the animal, which again expends some of the energy in the operation of collecting. If vegetable energy be supplied to the animal in a collected form, then a large portion of the directed energy is available for mechanical purposes. And in this way we may form a rough estimate of the directed energy to be obtained from sunshine in this country. The common agricultural rule is one horse or bullock to two acres, such a horse pulling 120lb. at a rate of 3·6ft. per second for eight hours a day. That is a nominal horse.

We thus get something like 3,000,000,000 over and above the energy necessary for the energy spent in eating the corn and moving itself, which we must put down as at least equal in amount. Taking only the available portion, we have the equivalent per acre of nearly three tons of coal burnt in such steam engines as exist at present. Now, the average weight of the vegetable produce from one acre, taking the form of straw and corn, would be about two tons. So that, as far as mechanical power is concerned, coal burnt in our present steam engines, and corn and straw eaten by horses, yield about the same energy, weight for weight.

The energy which we derive from sunshine is scattered all over the earth, and if it is to be utilised at any spot other than that at which the sunshine falls, it must be transmitted by the expenditure of power.

The energy required for immediate operations of agriculture absorbs a large proportion of the actual energy grown. The surplus is available for purposes of art, and we may say that the primary object of man has been to render this surplus as large as possible. This is accomplished, in the first instance, by applying the residue of energy to so ameliorate the conditions of agriculture as to increase the yield and diminish the labour. In this way the land is levelled, enclosed, and drained; buildings are erected, and finally, but most important of all, roads are made. The effect of roads in increasing the surplus energy is probably greater than any other human accomplishment. The only means of transmitting for purposes of collection or other purpose aggregate energy in the shape of corn, without roads, is on the backs of animals. In this way two or three hundred miles was the absolute limit to the distance an animal could proceed, carrying its own food. On a good road, a horse will draw a ton of food at twenty miles a day, which would mean that it would proceed 800 miles before it had exhausted its supply, or whatever surplus energy there might be available on one spot; half this would be available at 400 miles distance. The labour of maintaining the roads should, of course, be deducted, but this is very small.

The labour of constructing canals is very great, but the result is equal; a horse can move 800 tons twenty miles a day; or a horse could draw its own food for 80,000 miles on a canal. That is to say, with a canal properly formed, a horse could go five times round the world without consuming more energy than was in the boat behind it. Or corn could be sent round the world with a consumption of one-fifth. On railways, at low speeds, the force required is about ten times greater than on a canal, so that the expenditure in going round the world would be about equal to the total energy drawn. If for a moment we replace the horse by the steam engine, and the corn by coal, we have to add the weight of the engine to the coal, and diminish the efficiency by one-third; we so get that the consumption of coal for the same load of coal as of corn would be about double, or an engine would go about one-fourth round the world, consuming in coal the net weight in the train, that is exclusive of carriages and engine. Or for every thousand miles corn is carried by rail, something like 10 per cent. of the energy of the corn is expended in draft. This is exclusive of the expenditure in wear and repairs, which will be certainly equal, if not greater. Taking, then, the mean distance by rail between London and the west of America as 2,000 miles, the present expenditure in the energy of corn in transit is somewhere about 10 per cent. The expenditure of energy on the ocean varies, but if transported by steam it would be probably 10 per cent. more, so that at the present time we are actually receiving available mechanical energy, transported in the form of corn, over 2,000 miles of land and 3,000 miles of sea, entirely by artificially directed power, with an expenditure of less than 50 per cent.; a proportion which 200 years ago would have had to have been spent in transmitting it fifty miles over land; a result which has been accomplished by the employment in the meantime of the residual energy over and above that necessary for agriculture, together with a further supply drawn from our coal beds.

Turning now our consideration to coal, we find per weight as used at present, this yields rather less power than corn, but not less than two-thirds, and it then appears that coal may be transmitted at the present time, between any two places on the earth which are connected by rail and water, with an expenditure of less than 50 per cent.

In instituting this comparison, the standard has been the actual available power, as developed in our present engines and in horses, with which, weight for weight, there is not much difference. But the adaptability of this energy, so developed for particular purposes, renders the one medium much more valuable than the other. Thus for agricultural purposes, weight for weight, horse food is worth in money ten times as much as coal. This shows the extreme difference in the value of energy according to its adaptability; and the extension, for which there is unlimited scope, of the adaptability of steam power, may render it ten times as valuable as at present; nor would this be any small proportion compared with the total energy employed in the work of the world. In this country there are said to be between two and three million horses, and we may put the labouring men down at five millions, or the total power derived from corn down as over three million horses. From the best information going, the work done by steam in this country does not exceed the labour of two million horses, so that more than half the energy is still derived from corn. A greater proportion of the actual corn used for horse food comes across the Atlantic; and for many years maize was sold in this country at an average price of £6 or £7 a ton, the cost of transit being a very small matter. Of course the same cost, say £1 per ton, applied to coal would be a serious matter, considering the low price of the latter. But if, in the present state of our art, energy can be transmitted by corn from any part of the world to this country with an insensible rise, there is no reason to suppose but that, with the advance which science shows us, there is every reason to expect coal may be transmitted with a corresponding small increase in its cost, wherever the demand for it is sufficient to recompense the outlay necessary for opening the roads or canals.

(TO BE CONTINUED.)

Numbers of "The Electrician" out of Print.—The following numbers of *The Electrician* are out of print, and cannot be supplied at the office, viz.:—Vol. 1, Nos. 3, 9, 19; Vol. 7, Nos. 8, 10, 12 to 18, 20, 21, 24 to 26; Vol. 8, 1, 3, 6 to 12, 15 to 26; Vol. 9, Nos. 2, 4, 24, 25; Vol. 10, No. 13.

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THE NATIONAL TELEPHONE COMPANY (LIMITED), GLASGOW.

The third annual *conversazione* of the above Company was held on Friday evening, the 19th instant, in the Fine Art Galleries, Sauchiehall-street, which were beautifully decorated with exotics, &c., for the occasion, the effect of which on the magnificent staircase was very fine. There was a large and brilliant assembly of the *employés* and friends, and also subscribers. The programme, which was an exceedingly well arranged one, included several musical pieces of a high character, rendered by local talent of no mean order. A large number of representatives (ladies and gentlemen) were there by invitation from the Company's various centres in Aberdeen, Belfast, Dundee, Edinburgh, Greenock, &c. In the course of the evening Wm. Alexander Smith, Esq., resident director, occupied the chair, and was accompanied on the platform by Messrs. P. Rottenburg, J. E. Watson, L. Cowan, J. L. Mitchell, D. J. Smith, and George Melville.

At the outset the chairman read letters of apology from Sir William Thomson, Lord Provost Ure, &c., and after regretting the absence of Colonel R. Raynsford Jackson, the chairman of the Company, who was unable to be present, congratulated the *employés* on the progress which the telephone had made in Glasgow. It was only two and a half years since they had introduced to Glasgow one of the greatest triumphs of modern science—that useful invention the telephone [applause]. When he recollected the beginning of this Company amid a chaotic mass of telephonic arrangements and inventions, and when he looked round him and remembered what the telephonic system was now, they would agree with him that he was entitled to feel somewhat proud at their having arrived at their present high standard of excellence. Then, as it was well enough known, the subscribers numbered about 290 in Glasgow, and they now figured above 700, in addition to over 200 private lines. Over these fully 4,000 messages passed daily. He then compared the number of messages passing over telephone wires with the number transmitted along telegraphic wires in the metropolis, and drew conclusions from statistics favourable to the Telephone Company. One thing he was glad to say, that the success attending the establishment in Glasgow was repeated in Aberdeen, Dundee, and the other centres of the Company, and they had now over 4,000 miles of line wire. He then briefly referred to the *esprit de corps* which existed between the various districts, and after referring to the advantage to be gained by attending the Company's electricity classes, cautioned the younger members on the evil result of delaying to acquire a technical and scientific knowledge of their profession, as "the mill could never grind with the water that is past."

A vote of thanks having been awarded to the *conversazione* committee for the successful manner in which they had catered for the enjoyment and comfort of those present, dancing was resumed, when—

Hornpipes, jigs, strathspeys, and reels,
Put life and mettle in their heels.

The toilets of the ladies, however, were somewhat different from those witnessed by Tam O'Shanter, the hero of the poem of which the above is a quotation, being of the most elaborate description, and contrasted well with the general *entourage*.

YORKSHIRE BRUSH ELECTRIC LIGHT AND POWER COMPANY (LIMITED).

An extraordinary general meeting of this Company was held at the Terminus Hotel, Cannon-street, on the 23rd inst., to consider the following resolutions, viz.:—

1. That it is expedient to effect an amalgamation of the Yorkshire Company with the Hammond Electric Light and Power Supply Company (Limited) (hereinafter called the Hammond Company).

2. That the agreement now submitted to this meeting, and expressed to be made between the Yorkshire Company of the one part and the Hammond Company of the other part, be, and the same is, hereby approved, and that the Board of the Yorkshire Company be, and they are hereby, authorised to carry the same into effect.

The SECRETARY (Mr. G. L. Morton) having read the notice convening the meeting,

The CHAIRMAN said: When we last met to consider the balance-sheet I stated to you that we were then on the point of concluding an arrangement for the amalgamation of our business with that of another company. Shortly afterwards we arrived at an agreement, and in accordance with our promise we lost no time in advising you of the terms of that agreement, and convened this meeting to consider the same. I think, on a fair consideration of these terms, that they must so thoroughly recommend themselves to the mind of every one who has carefully studied our position and prospects, as well as the difficulties that lay before us, that we shall, I hope, all arrive at the conclusion that they are acceptable. It has been evident to the Board lately that we cannot recommend to our shareholders the continuance of the business with its present burdens. The transfer we now propose will remove those burdens from us, and in exchange for our unmarketable security in shares, we shall have an interest-bearing, saleable security, which alone is a very desirable thing. I noticed that the Hammond shares, on which £3 15s. has been paid, were quoted quite recently at £3 10s. There is a further call upon those due towards the end of the year of £1 5s., so that if we add that to the £3 10s., the market price, we find that the market value we are to receive for our six shares is £4 15s. That is equal to about 16s. a share of our capital, and I think those terms must be admitted to be favourable to us. No doubt they are also favourable in some measure to the Hammond Company, because with the expenses removed from them I see no reason why, in a fair time, the business which we shall hand over to the Hammond Company will not be a remunerative one, and one on which they may congratulate themselves. The staff they have is able to work our business, and by that means they save a very large expenditure, which makes the work they do result in profit, while with us it results in loss. It is not so very long since the Hammond shares were quoted at a very large premium, and I see no reason at all why in the future, with the prospects before them, the same thing should not occur again. In that case our shareholders who choose to hold on to the new shares will be greatly benefited, and recoup themselves of a portion of the nominal loss they sustain. I will now ask the solicitor to read the draft of the agreement, and then I shall move the resolutions that appear in the notice calling the meeting.

The SOLICITOR (Mr. Browne, of the firm of Messrs. Linklater and Co.) accordingly read the agreement, which provides for the amalgamation of the two companies on the terms of the Hammond Company surrendering to the Yorkshire Company the 17,060 fully paid-up shares in the Yorkshire Company which it still holds, and also agreeing to allot and issue to the Yorkshire Company for distribution amongst its shareholders fully paid-up £5 shares of the Hammond Company in the proportion of one fully paid-up £5 share of the Hammond Company for every six £2 fully paid-up shares in the Yorkshire Company. The Yorkshire Company will, in consideration of this, transfer to the Hammond Company all its undertaking, property, assets, and effects whatsoever, the Hammond Company undertaking to bear and pay all liabilities, and also the costs of the agreement, and of winding up and dissolving the Yorkshire Company, which will be proceeded with as soon as the amalgamation is carried out.

The CHAIRMAN then moved the resolutions as above.

General J. BATES having formally seconded the motion,

Mr. M'ALISTER asked for some information of their prospects after the amalgamation.

The CHAIRMAN regretted that Mr. M'Alister was not present when he made his opening speech, the salient points of which he repeated. He added: I may mention, in support of my opinion as to the future value of the Hammond shares, that that company is about to make a similar arrangement with the Birmingham and Warwickshire Company to take over the business of that company. If two staffs are extinguished, and the business is carried on by a third company, we can understand how the work done may be far more remunerative than if carried on by the companies originally formed for the business. He then put the resolutions in the usual way, and having declared them carried, said: I think one of the shareholders at our meeting a few days ago mentioned that he had heard of our shares being sold at 5s. each. All I can say is that the lucky holder of those shares may consider himself very well off. It was a value perfectly imaginary.

A SHAREHOLDER asked what would be the position of those who held unequal numbers of six shares.

The CHAIRMAN replied that this point had not been adjusted yet; but they regarded it as a mere matter of detail.

A vote of thanks to the chairman terminated the proceedings.

COMPANIES' SHARE LIST.

TELEGRAPHS.

Companies.	Closing Prices Oct. 24.		Business Done Week Ending Oct. 24. Highest.	Lowest.
Anglo American	44¼,	45¼	45½	43⅝
Do. Preferred	74½,	75½	76	74
Do. Deferred	15½,	15¾	15¾	14¾
Brazil Submarine	10¼,	10¾	11	10¾
Cuba	10½,	11	11	10¾
Do. Preference	17,	18	—	—
Direct Spanish	5⅛,	5⅜	5½	—
Do. Preference	15½,	16	16½	—
Direct United States Cable	11½,	11¾	12	11¾
Eastern Telegraph	10¾,	11	11 11-16	10¾
Do. 6 per Cent. Preference	12¾,	13¼	13¼	12 15-16
Do. 5 per Cent. Debentures, 1899	104,	108	105	—
Eastern Extension	11⅜,	11⅝	11 11-16	11¼
German Union	10,	10½	—	—
Globe Telegraph and Trust Company.	7¼,	7½	7¼	7½
Do. Preference	12¾,	13	12 15-16	12 13-16
Great Northern	12¾,	13⅛	13	—
Indo-European	32,	33	32¾	—
Mediterranean Extension	1¼,	1¾	—	—
Do. Preference	2,	4	—	—
Reuter's	8½,	9	—	—
Submarine	215,	225	220	—
West India and Panama	¾,	1	15-16	¾
Do. 1st Preference	6½,	7¼	6⅝	—
Western Brazilian	5⅛,	5⅝	—	—
West. Union 7 per Cent. 1st Mortgage	122,	124	—	—
Do. 6 per Cent. Sterling Bonds	100,	103	—	—

TELEPHONES.

Companies.	Closing Prices Oct. 24.		Highest.	Lowest.
Consol. Telephone and Maintenance	¼,	½	7-16	5-16
Oriental	¼,	½	5-16	—
United Telephone	8,	8½	8½	8 1-16

ELECTRIC LIGHT.

Companies.	Closing Prices Oct. 24.		Highest.	Lowest.
Anglo-American Brush Lgt. (£7 paid).	2¼,	2⅝	2½	—
Do. (fully paid)	4,	5	4 7-16	4¼
Hammond Light (£3 15s. paid)	3½,	3½	3¾	3
Eastern Electric (£4 paid)	1,	1¼	—	—
Swan	1¾,	2	2	1 13-16
Maxim-Weston	⅛,	¼	¼	—

MISCELLANEOUS.

Companies.	Closing Prices Oct. 24.		Highest.	Lowest.
Telegraph Construction	36,	36½	36¼	35¾
India Rubber, Gutta Percha, and Telegraph Works	30,	31	31	30¼

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NOTES.

Electric Lighting, Contract, and Maintenance Company.—The liquidators have returned the whole of the share capital, less $4\frac{1}{2}$ per cent., to the shareholders.

Eastern Telegraph Company.—This company's traffic receipts for the month of October, 1883, amounted to £47,624, and to £85,173 in the corresponding period of 1882.

Amalgamation.—The Hammond Company is, it is stated, to re-absorb the Yorkshire Brush Company. It will be remembered that the latter is an offspring of the former.

The Lane-Fox Lamps.—It is said that the present factory for these lamps is to be closed, and the manufacture carried on at the Brush works in Belvedere-road, thus obtaining a considerable saving in expense.

Amalgamation of Gas Companies.—It appears that the proposed amalgamation of the South London and the Gaslight and Coke Companies will require the sanction of the Board of Trade, who are now inviting the opinions of the local vestries on the subject.

Dunfermline.—A Dunfermline correspondent reports that during a recent thunderstorm the effects of lightning were displayed in an extraordinary manner in the suburb of Brucefield, where 17ft. of wall 14ft. high were demolished, and a bank 40ft. by 6ft., facing it, was torn away.

Huddersfield.—A part of one of the largest woollen factories in Huddersfield, that of Messrs. John Taylor and Son, is now fitted with 200 incandescent lamps run from a Ferranti dynamo machine. The installation has been made under the direction of Mr. Alfred Thompson.

The Explosions in the Underground Railways.—In both the Metropolitan and the District Railway tunnels the explosions of Tuesday night destroyed the telegraph wires on the spot and caused temporary interruption of traffic, the safe working of which is mainly dependent on telegraphic signalling.

Finsbury Technical College.—The Lord Mayor elect has consented to preside at the presentation of prizes to the students of the Finsbury Technical College and of the South London School of Technical Art, as well as to the successful candidates from the Metropolitan centres at the May Technological Examination.

Is it a Joke?—We mentioned recently a true tale of a railway company's charges, but the following is perhaps better. We are told that a gentleman ordered some Swan lamps. The lamps were invoiced to burn with 45 volts. A reply came back that the lamps had been safely received, but that, though the packages had been carefully hunted through, no sign of the 45 volts was to be found.

Incandescent Lamps.—Would it be surprising to many readers to learn that incandescent electric lamps were used forty years ago to illuminate a mine? We are so accustomed to be led away by the rapid progress of the last few years as to forget the work of pioneers. Carbon in a vacuum was used in the lamps above referred to, but of course the vacuum was not so high as that at present used, because the apparatus for obtaining it was not so perfect.

The Fisheries Exhibition.—This exhibition, which closed on Wednesday evening, has been highly successful in every respect. The number of visitors up to the day previous to closing amounted to 2,689,092, the daily average being 18,545. Its financial results are equally satisfactory, there being a considerable margin of profit after all expenses are paid. The attendance in the evenings, we need hardly remind our readers, has been largely due to the splendid illumination by electric lighting, the best, probably, ever yet displayed.

Woolwich.—A novel application of photography to the art of gunnery has been introduced at the Royal Gun Factories by Col. Eardley Maitland, R.A., superintendent, and some very successful plates have been taken showing defects in the bores of guns sent back for examination after trial. The electric light, powerful lenses, and mirrors are employed for this purpose, and Mr. H. Baden Pritchard, of the Royal Arsenal Chemical Establishment, who has charge of the photographic branch, is contriving a special apparatus to simplify the process.

Electric Lighting at Brighton.—The Brighton Town Council have decided by 18 to 15 votes to apply to the Local Government Board for sanction to borrow £60,000 for electric lighting purposes. A site for a central station has been selected to serve the area which the corporation are first bound by their provisional order to supply, and the earliest consideration will be to light the sea front, which it is thought when illuminated throughout its length of three miles will present a brilliant if not unique spectacle. It was also decided to complete the electrical lighting of the Royal Pavilion.

The Society of Telegraph Engineers and of Electricians.—The members of this society, accompanied by lady friends, held a *conversazione*, under the presidency of Mr. Willoughby Smith, at the South Kensington Museum, on Thursday evening last. An account of the gathering will appear in our next issue. The first ordinary general meeting this winter will be held by the Society at the Institution of Civil Engineers, 25, Great George-street, Westminster, on Thursday next, 8th inst., at 8 p.m., when a paper will be read by the president, Mr. Willoughby Smith, on "Volta-Electric Induction," illustrated by experiments.

Sixpenny Telegrams.—Commenting on Lord John Manners's letter to *The Times*, which we reprint below, the *Echo* remarks:—"The announcement made by the Chancellor of the Exchequer in his Budget speech that the Government was prepared to agree that the minimum charge for inland postal telegrams should be reduced to sixpence was received with general satisfaction; but, as we pointed out at the time, and as Lord John Manners shows very conclusively this morning, congratulations on this score were premature. As a matter of fact, there will be no sixpenny telegrams, and the concession made by the Telegraph Department is more apparent than real!"

Telephonic Æsthetics.—In addition to the ordinary wires which have long disfigured the neighbourhood of the Law Courts, two thick cables have now been swung at an oblique angle from the opposite side of the Strand to the roof of a building adjoining the Courts, giving an appearance to the clock tower of being held up by ropes. If any of these architectural embellishments happen to give way, the Griffin, over whose wings they are suspended, will assuredly suffer. Perhaps this is the reason they have been allowed to take up their present position, the silence of the Press, which was loud in condemnation of the Temple Bar "memorial," being otherwise unaccountable.

Special Study.—Sir Farrer Herschell, Solicitor-General, addressing the students of the Durham Science School, on Monday evening, said that if he had to live his life over again he should endeavour, before the practical work of life began, to make himself thoroughly acquainted with some branch of natural science. Dwelling upon the advantages to be gained by the study of modern sciences, especially that of electricity, he strongly deprecated the practice of those who endeavoured to make the whole world of science their study.

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He advised students to thoroughly master one branch before taking up another, and to limit their studies to complete mastery of the subjects taught.

ELECTRIC LIGHTING IN CHURCH.—St Matthew's Church, Brixton, was lit by the Fyfe-Main system on Sunday last. It is believed that this is the first English Established Church which has been lighted by electricity. To light the edifice four arc and 60 small incandescent lamps were brought into requisition. The former were placed in the roof, while the smaller lights were distributed over the lower parts of the building. The result was very satisfactory, the church being suffused by a fine softened light, which burnt with great steadiness. The inventor claims for his system that it can be used in large public buildings at a fifth of the cost of gas for the amount of light given. The light will be permanently used in St. Matthew's Church.

BRAZILIAN SUBMARINE TELEGRAPH COMPANY.—This company's shares are the subject of much attention, a great deal of questionable business being done daily in them. During the last few weeks the shares have fallen from 12 to about 9, and the cable is the subject of anonymous circulars urging holders of the shares to sell, &c., on the ground that the breakage of cables will sweep away the reserve of £407,000 which had been accumulated, and that the directors have got rid of their holdings. It may be pointed out, however, that the reserve was accumulated for no other purpose than to restore the plant of the company when requisite, and inquiry as to the reduction of one or two of the directors' interests elicits complete and satisfactory explanations.

THE TELEPHONE FOR MEDICAL USE.—This useful appliance is slowly but surely making its way among the medical profession in Dublin. In addition to the College of Physicians and to the College of Surgeons, no less than nine hospitals have joined the exchange, viz., Cork-street Fever Hospital, Jervis-street Hospital, the Mater Misericordiæ Hospital, the Meath Hospital, Mercer's Hospital, the Richmond Hospita St. Vincent's Hospital, Steeven's Hospital, and the Orthopædic Hospital. Sixteen physicians and surgeons, mostly hospital medical officers, have telephones, while six medical halls and several wholesale pharmaceutists are on the exchange, and can thus receive prescriptions, or refer to medical men when necessary regarding prescriptions which have been sent in the ordinary way.

THE SUBMARINE CABLES CONFERENCE.—The convention agreed to by the Conference will apply, outside territorial waters, to all submarine cables legally established which touch land on the territories or possessions of the contracting parties. The latter bind themselves when they authorise the landing of cables to impose conditions for the protection of the cables, and ships employed in the laying or repairing of cables will have to observe the rules adopted by common agreement for the avoidance of fouling. The tribunals competent to deal with infractions of the present convention are to be those of the country to which the ship in fault belongs. States which have not been represented at the Conference will be permitted to give their adhesion to the convention on application. The ratifications will be exchanged in Paris within a year's time.

EARTHQUAKES.—Particulars of the earthquake shock experienced at Smyrna state that the wall surrounding the town, the Aqueduct, and the Hadji Hussein Mosque have been damaged. The minaret and dome of the Hadji Ali Mosque at Capan Vourla have also been injured. At the last named town one hundred and sixty-nine persons have been seriously, and sixty-one slightly, hurt. Seventy-nine wounded people are in the hospitals. On the 27th ult. a shock of earthquake was felt at Tashkend, in Turkestan, accompanied by loud subterranean rumblings. Intelligence also reaches us from Bermuda of a sharp shock having been experienced in that place on the 20th, but without doing damage. On the evening of the 29th, at forty minutes past nine o'clock, a shock of earthquake, lasting thirty seconds, and accompanied by subterranean rumblings, was felt at Kamenetz, the chief town of Podolek, Russian Poland.

FACTORY LIGHTING.—A very successful application of the Ferranti system to the lighting of a woollen factory has recently been made at the works of Messrs. George Brook, jun., and Co., of Bradford, the result being so entirely satisfactory that the firm has decided not to lay on gas, the mill being, therefore, entirely dependent on the electric light for its illumination. An experiment was in the first place made by fixing incandescent lamps on movable brackets on to the looms, but this plan had to be abandoned in consequence of the vibration of the frame of the looms, caused by the motion of the shuttle frame. The lamps were next fixed on telescope brackets, with movable joints, suspended from the roof over the looms, so as to admit of the lamp being moved about in any direction. The efficient lighting of every part of the looms was thus fully secured. The installation was made under the direction of Mr. Alfred Thompson.

ELECTRICITY IN THE TORNADO.—While accounts differ as to its appearance and behaviour, as witnessed from different points of observation and under different circumstances, all substantially agree that it is cone-shaped, its motion rotary, that its apex resembles fire and smoke, and that vivid lightning and heavy rain-fall usually accompany it. In rare instances electricity, in the form of St. Elmo's fire, will precede the vortex, and a white, steamy cloud will follow. It will be observed that the form of the tornado-cloud is nicely illustrated by the "proof-plane" used in teaching natural philosophy. The small end of the plane is most heavily charged with electricity, and the nearer it approaches to a perfect point, the greater will be the accumulation; a high tension is caused, and the electricity must escape by some conductor. So, in the tornado cloud, the smaller the point or stem the greater the force exerted when it meets the earth.—*Geo. C. Smith in Popular Science Monthly.*

ACCIDENT TO A TELEPHONE WIRE IN THE CITY.—Shortly before eleven o'clock on Saturday forenoon a serious accident occurred in the city through the falling of a telephone wire. It appears that several workmen in the service of the Globe Telephone Company were engaged in removing wires extending from 3, Frederick's-place, Old Jewry, across Gresham-street, to Gresham-buildings, Basinghall-street. One of the wires slipped through the hands of the man who had hold of it before it was properly secured by a guiding rope, and came down with a crash amongst the people passing to and fro in this crowded locality. The hats of a number of gentlemen were knocked off, and several very narrow escapes were made as the wire twisted and turned in serpent-like fashion in the air. The most serious injury was sustained by an elderly lady, whose name was ascertained to be Mrs. Emma Street, of Englefield-road, Islington, and who was badly cut across the head and face. She was at once removed to a neighbouring office by Constables Hunt and Watson, of the City police, and, as she declined to go to a hospital, she was driven home in a cab by a friend, in a fainting condition. The occurrence caused a great sensation at the time.

DOMESTIC LIGHTING.—The electric light is making considerable progress as a means of lighting up large country mansions. We understand that Messrs. J. Edmundson and

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Co., of 19, Great George-street, Westminster, who make a speciality of lighting country houses, have a great many installations in hand. Among other works, this firm has at present in hand, or have recently completed, the following country mansions:—Didlington Hall, Norfolk, for W. A. Tyssen Amherst, Esq., M.P.; Membland Hall, Ivybridge, for E. C. Baring, Esq.; Warter Priory, near Hull, for C. H. Wilson, Esq., M.P.; Linden Park, Hawick, for Walter Laing, Esq.; Chesterford Park, Saffron Walden, for G. W. Brewis, Esq., and Glendalough House, co. Wicklow, for C. W. Barton, Esq. Messrs. Edmundson and Co. are also introducing the electric light into a large new mansion at Champion Hill, building for Egmont Bieber, Esq. They also recently fitted up the flour mills of Messrs. Trevithic and Sons, of Hayle, Cornwall. In all these installations the Swan incandescent lamps are used. The motive power varies, being in some cases steam engines, in others gas engines, whilst in two cases sufficient water power has been obtained to work turbines. The various fittings are all designed and manufactured specially, and are in some cases of very elaborate design.

The Fixing of Telegraph Wires in the City.—In the City of London Court on Monday last, before Mr. Commissioner Kerr, an action was brought by Charles Clynch, a telegraph wireman, against the Electric News Telegraph Company, of Ludgate-circus, to recover damages for alleged wrongful dismissal. The plaintiff stated that after having been in the employ of the defendants for some time at a weekly wage, he was summarily dismissed on a Friday morning, having been paid only up to the previous night.—His Honour: But there must have been some reason for dismissing. What was it?—Plaintiff: I really cannot say. I have an idea that it was because I would not steal on to the roof of No. 7, Winchester-buildings, City, to attach a wire to a part of it without the consent of the housekeeper.—The defendant's solicitor: I shall prove that he positively refused to do his work according to instructions. If he were told to fix the wire upon a particular building it was his business to do it. The company would be liable for any wrong, not him, and beyond that he absented himself without consent.—Plaintiff: That I deny. On the day previous to my discharge Mr. Lambry, my manager, gave me permission to attend a funeral with my fellow-workman, and hence my absence.—Mr. Lambry was called, and denied having given the permission, and stated that in addition to absenting himself without leave he refused to work with another man, and had destroyed the communication in a wire which he was fixing by puncturing the gutta percha covering, and thereby causing the current to "run to earth."—His Honour said as it was oath against oath, he gave the plaintiff leave to have a trial by a jury.

Electric Lighting at Bolton (Lancashire).—Mr. W. Banks, of Bolton, has just completed the first part of an electric light installation at the Bolton Co-operative Stores' new premises in Bridge-street. For some time, in fact ever since the building was erected, the ventilation of the upper rooms in the winter months was very unsatisfactory when gas was burning, and the board of management decided to adopt the incandescent light as a ready means out of the difficulty. The result is entirely satisfactory, as with gas the temperature rose to 85deg., and now, with the new light, it scarcely ever exceeds 65deg. The assistants, especially in the drapery department, speak very highly of the light, as by it they can distinguish more readily the different shades of materials. Swan 20 candle-power lamps are used. The lights are arranged in groups of eight, supported by brass electroliers. Switches and safety plugs are placed in each circuit. The plugs will meet with an excess of 20 per cent. of current. The dynamo is one of the Elphinston and Vincent 400-light machines made by Messrs. Paterson and Cooper. At present 150 lamps are being used, and with this number on the machine is required to run at 800 revolutions per minute, giving an E.M.F. of 110 volts. The motive power is derived from the engine which does the ordinary work of the business, viz., hoisting, coffee grinding, &c. The dynamo is situated at the central shops some 150 yards distant from its work, the current being conveyed by two stout copper cables covered with Callender's core. The whole of the fittings have been made expressly for this contract by Mr. Banks, at his new workshops in Lorne-street.

Dunphail House.—We understand that Lord Thurlow is about to introduce the electric light into Dunphail House. The dynamo to be employed will be constructed by the Anglo-American Brush Company, of which Lord Thurlow is chairman, and will be driven by a turbine, the water-power being taken from the river Divie. It is intended, besides lighting Dunphail House, offices, and home farm, to use electricity as a motive power for driving the threshing, sawing, and other mills on the estate. A local paper says: "Lord Thurlow requires no steam to produce the electric light. The Divie, a wild stream, tumbles down past his house, offices, and farm buildings, through a most romantic and beautiful valley. In summer it is sometimes not large in volume, but towards autumn, all through the winter, and generally during spring, it is a stream of goodly size. These are the periods of the year when lighting and farm machinery are most in use. Then any quantity of fall for a turbine can easily be got on the Divie. It will require strong works, however, to keep floods from sweeping everything away. Sir Thomas Dick Lauder immortalised the power of the Divie in its wildest moods in his 'Moray Floods of 1829.' The genial baronet had his residence then by the side of it at Relugas, down the valley a little way from Dunphail, and his very highest descriptive powers were employed to let his readers see what it was like, and what havoc it did on that memorable occasion. It will be a most pleasing triumph in science to see this erratic, wayward little river, which has pursued its lonely but most romantic way from the mountains down to the Findhorn almost without interference for, who shall say how long? putting machinery in motion for drawing electricity from its storehouses to illuminate the abodes of those who live on its banks, and perform much of the work in which the people of the valley were in past times employed."

Overhead Wires in London.—The united committee appointed by the vestries of St. Marylebone and St. James, Westminster, on "Overhead Wires in London," has presented its report to the vestries. The united committee considers it to be desirable that one local representative authority, acting for the whole of the local authorities of London, should take action forthwith, in order to test the powers of the existing law on this question; that the Vestry of St. Marylebone, as such representative body, shall be invited to take such action; and the united committee further suggests that the action should be the issuing of a notice to all persons, public or private, having wires in or over the streets and thoroughfares of the capital, that application for permission to continue telegraph, telephone, or other wires in the parish of St. Marylebone must at once be made to the vestry of the parish, and that without such permission being given no wires shall at any time be laid under or be raised over the streets in any part of the parish; that in the case of every existing raised wire for which applica-

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tion shall not have been made within fourteen days of the issue of the notice for permission for its continuance, such wire or wires shall be disconnected under the superintendence of the surveyor of the parish on the order of the vestry; that no new wire shall be laid under, or be raised over, the streets and thoroughfares of the parish by any person or persons whomsoever until permission for the laying, or for the raising, of such wire or wires has been first granted by the vestry. Should an appeal to the courts of law be rendered necessary, the vestries and district boards are to be invited to assent to such action, and to declare their readiness to bear their share of the costs, *pro râta*, that may be necessarily incurred in finally determining the powers of the local authorities to deal with telegraph, telephone, or any other wire or wires in the streets and thoroughfares of London. The St. Marylebone Vestry are now considering the report, and copies of it are to be sent to members of the Government and local bodies.

The late Postmaster-General on the Reduced Tariff.—In a letter to *The Times* of Tuesday, Lord John Manners writes as follows :—" May I call the attention of the telegraphing public to a danger which threatens them in the coming year? In their presumed interest Dr. Cameron moved and carried on the 29th of March a resolution ' that the time has arrived when the *minimum* charge for Inland postal telegrams should be reduced to 6d.,' and, in consequence, the Chancellor of the Exchequer announced in his Budget speech that the Government accepted the principle of a reduction in the *minimum* price of telegrams. This decision was explained and amplified by a Treasury minute of June 20, and it is to the project set forth in the latter document that, in the interest of the telegraphing public, I take exception. One of the boons promised and secured to the public by the Act which transferred the telegraph service to the State was free addresses, and to it they have become accustomed, and, unless I am mistaken, attached. They have also been accustomed to and appreciate the privilege of sending a fairly long message (20 words) at the initial charge of 1s. Many people, when told they are to have sixpenny telegrams fancy no change will be made in those two important particulars, and, of course, if the Treasury were able and willing to concede such a reduction everybody would gratefully accept it. But a perusal of the Treasury minute will dispel any such illusion. Three schemes are discussed, and the third, which alone maintains free addresses, is condemned, while not one of them continues the present convenient arrangement of extending the initial charge over 20 words. The permitted alternative is between two complicated schemes, by the first of which free addresses are to be altogether abolished, while by the second the address of the receiver is to be free, that of the sender to be charged a halfpenny a word. Under the first scheme it is obvious there can be no 6d. telegrams; 8d., 9d., 10d. telegrams there may be, attended with great confusion and perplexed attempts on the part of the unfortunate senders to compress the addresses and the telegrams within the narrowest limits compatible with safety—attempts certain in innumerable cases to miscarry—to the annoyance alike of the public and the department. The same objection, though with mitigated force, applies to scheme No. 2. There the temptation to the sender would be to insert his name and address in the body of the message, in which attempt he would probably find himself foiled by the extra 2d. charged upon every word after the first five words. In no case, therefore, will there be 6d. telegrams really available for the public, and just in proportion as the senders and receivers are humble and unknown will it be necessary for them, in order to secure the delivery of their telegrams, to be liberal in paying for the addresses. The gain will be to the rich and well known ; the loss either of money or telegrams, or both, to the poor and undistinguished. Mr. Fawcett has shown such anxiety to bring all classes within the scope of the improvements he has effected in various branches of the department, that did I think I was opposing in this matter my judgment to his I should probably forbear to express it ; but from his public utterances, no less than from the whole tenor of his administration, I feel confident of his sympathy when I deprecate in the interest of the humbler class of the telegraphing public the abolition, total or partial, of free addresses." On this subject Lieut.-Colonel Webber wrote to *The Times* the following day :—" When a Conservative Postmaster-General appeals in the interests of the million to his successor against any ' new telegram ' scheme which will do away with the free address now in use, a Liberal Postmaster-General will find it hard to withstand. The commercial instinct of the great body of the Post Office world, from the secretary downwards, must contemplate the result with dismay, because they know that a uniform sixpenny rate with a free address means financial ruin, or the sacrifice of a large part of the efficiency and celerity for which our Postal Telegraph Department is unrivalled, success in both of which is intimately bound up with the *esprit* of this our busiest branch of the public service. So imminent is the danger on one hand or the other, that I venture also to call the attention of the public to the system of ' deferred telegrams' advocated by me before Dr. Lyon Playfair's Committee of the House of Commons in 1876—a system which permits of the use of sixpenny messages under present conditions (or with twelve instead of twenty words in the body of the message) but subject to be delayed so long as shilling messages remain on hand. These messages may be called ' deferred' or ' second class' messages, and can be distinguished by the use of paper differently tinted to the white and red message forms now in use. I obtained at the time ample evidence from practical telegraph officials and operators that in a very few days such a system could be grafted on to the existing one with fewer complications than those now anticipated by Lord John Manners for the systems under consideration. The hours during which thousands of miles of telegraph wire are now idle would be utilised for sixpenny deferred messages. On lines of first importance the shilling rate and present conditions of speed would prevail ; on those of minor importance, such as those on which not 50 messages a day now pass, ' deferred messages' would experience little delay. The Australian Telegraph Administration has practically adopted this system in late years. Its opponents foretell for it that the sixpenny rate would be used almost exclusively, and the revenue fall off nearly as much as if that rate was uniform ; but all postal experience shows that this would adjust itself to the exigences of ' senders,' and no opponent can deny the economic value of giving precedence to shilling telegrams on wires already fully worked, and of the direct inducement to the public to utilise hours, wires, and offices, at present comparatively idle. Opponents will add that the Press uses most of the night work of the present staff; but, after all, this service applies chiefly to main lines, the use of which it is no one's wish to cheapen, except out of working hours. There is a vast field of use for idle wires between the close of the busy hours of one day and their commencement on the next. Why spend money on fresh wires (this is now being done by the Post Office in anticipation of a sixpenny rate) while an unused margin of capacity remains?"

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THE FERRANTI "THOUSAND LIGHT" DYNAMO.

It may be a very unscientific, but it is a very common way of designating a dynamo by the number of lamps of the

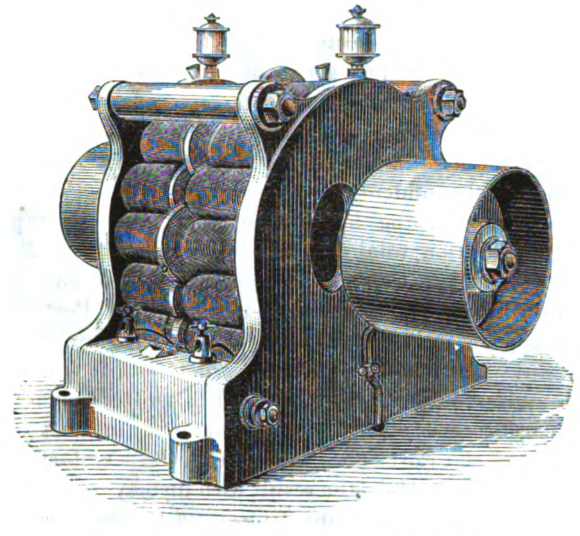

FIG. 1.—Ferranti Thousand Light Machine.

normal type which it is intended to supply with current. We may therefore be excused if we in this instance follow the lead of the multitude. On Wednesday, October 17th, an experimental run was made with the dynamo which has been

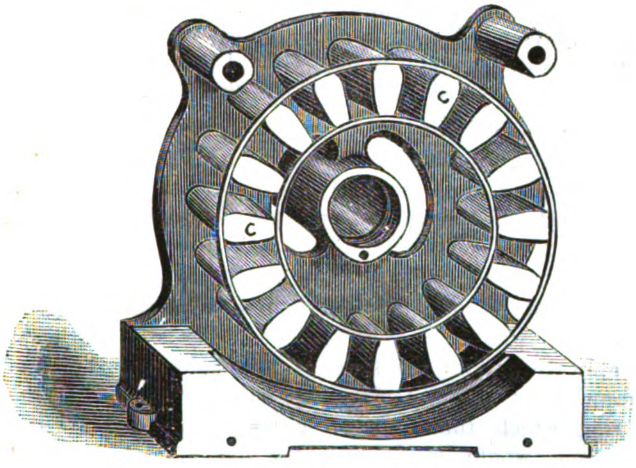

FIG. 2.—Inside View of Carcass.

built by the Ferranti Company for the First Avenue Hotel' at the works in Appold-street, Finsbury. The impression most people have of a thousand-light machine is that it will be large, occupying much space, and weigh several tons, and there-

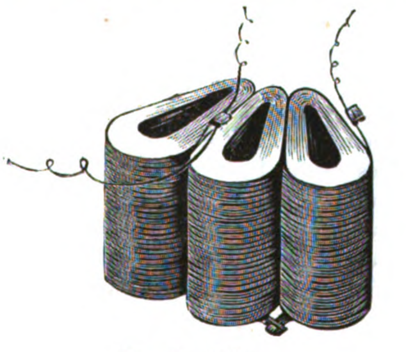

FIG. 3.—Coils.

fore they can scarcely realise that such a machine may prove to be comparatively small. We are becoming accustomed to see large heavy machines, such as the Edison, the Gordon, that exhibited at Vienna by Ganz, and so on, and it requires an effort of the imagination to realise that the Ferranti machine is calculated to replace those named. The base plate of the Ferrant thousand light machine is 39·5in. × 16in., the pulleys projecting over the base plate by about 14in. on each side. The total breadth, therefore, is 44in., that is 2 × 14 + 16. The height of the machine is 34in., so that we may write the size over all as 39·5 × 44 × 34in. Roughly speaking, the machine may be said to be constructed of two similar halves, between which the armature revolves. The complete

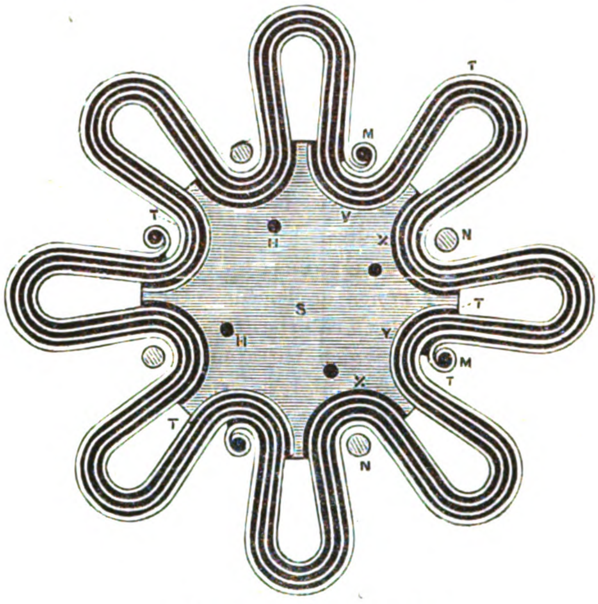

FIG. 4.—Type of Armature.

machine is shown in Fig. 1. The shaft is of steel, 2·25in. diameter, and 42in. in length, with bearings of phosphor bronze, the bearings being 9·75in. long. The pulleys are 15in. diameter and 12in. face. Fig. 2 shows one of the halves of what may be termed, after the fashion of Dr. Lodge, the carcass of the machine. These parts are cast. The face of the magnets, C C, is then planed up and the holes for shaft and bolts bored out. It will be seen that there is a ring encircling the ring of magnet cores. This ring is of brass, and is fastened by screws to each core, the

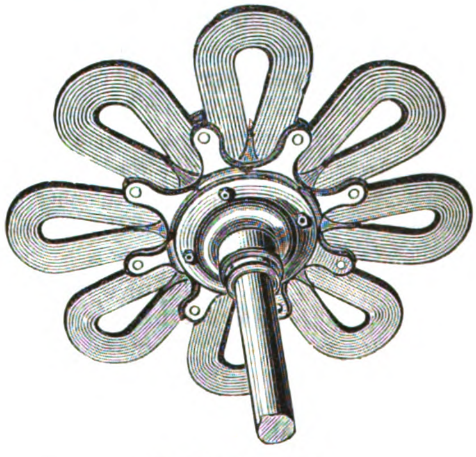

FIG. 5.—Armature.

latter being cut away slightly to fit the brass ring. The use of the brass ring is to keep the magnet coils in position, and although mentioned here is put on after the coils. The carcass being cast and planed up, a piece of vulcanised fibre is taken, and holes cut out to allow the fibre to pass over the cores, and the shaft to pass through; the fibre is then placed upon the iron carcass, and forms an insulation between the coils and carcass. It will be found that vulcanised fibre is very extensively used in the construction of these machines, but before use it is well varnished

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with shellac and baked. This process has been found to get rid of various difficulties which others have met with in the use of the fibre. The coils for the cores are wound separately in the lathe. A movable core piece slightly taper is taken and flanged with removable flange pieces at each end. In the flange is cut a small groove, the use of which will be seen directly. A short connecting piece of tin-covered copper wire is soldered to the wire to be used in winding the coil, and laid in the flange groove, which it fits exactly. Before the winding is commenced, however, a thin sheet of vulcanised fibre is put upon the core. The winding then goes on, each layer being shellacked, and the complete coil has also a coat of shellac. The other end of the coil has now a connecting piece soldered on, when it is slipped off the core, baked, and put

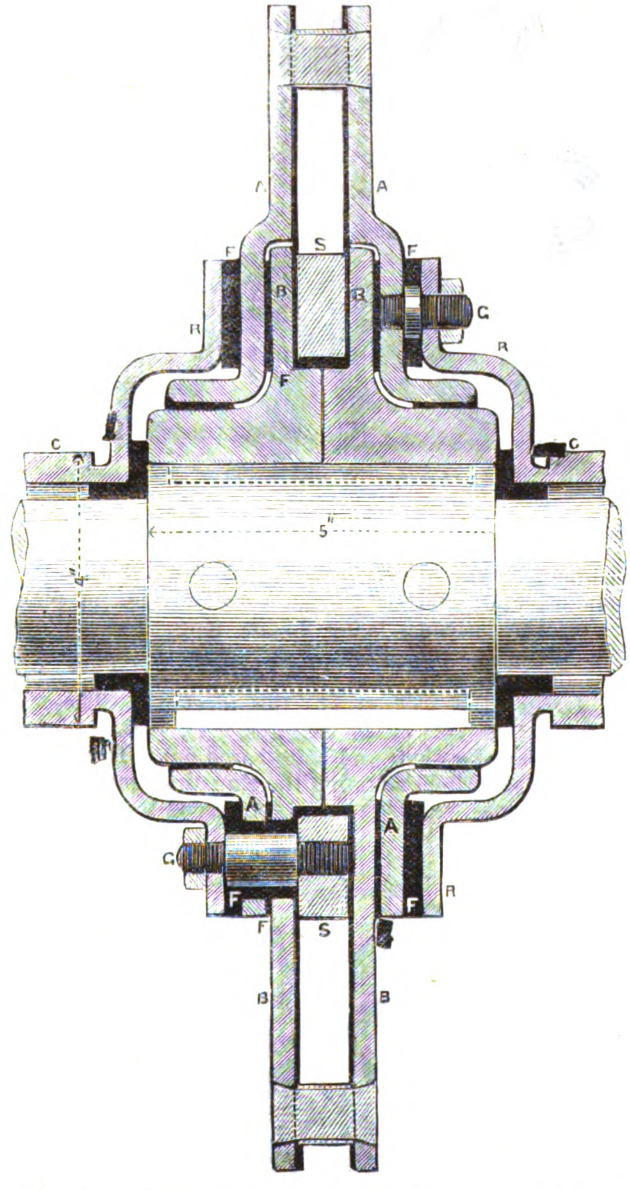

FIG. 6.—Section through Rubber Boss on line A A, Fig. 7.

upon the core of the machine. The connections are made so that all the magnet coils are in series, and that alternate poles are N and S. The total resistance of the field magnets of the machine under notice is 7·57 ohms. When the two halves of the machine are brought into position opposite poles are opposite in sign, that is, a north pole is opposite a south pole, and so on. In this machine there are 32 such coils, weighing altogether 6cwt. 3qrs. 20lbs. They are wound with wire 3·5mm. diameter, or about No. 10 B.W.G. Each coil has seven layers of wire, and each layer 48 convolutions. Fig. 3 shows these coils.

Passing now to the consideration of the armature—for it is in the armatures that dynamo machines principally differ —Fig. 4 is an illustration to show the type-form, and assist partly to make clear the description of the building up of the armature. The black lines are to represent the insulation-vulcanised fibre, the white lines represent the copper strips, the shaded portions represent a star-shaped piece of brass, which may hereafter be

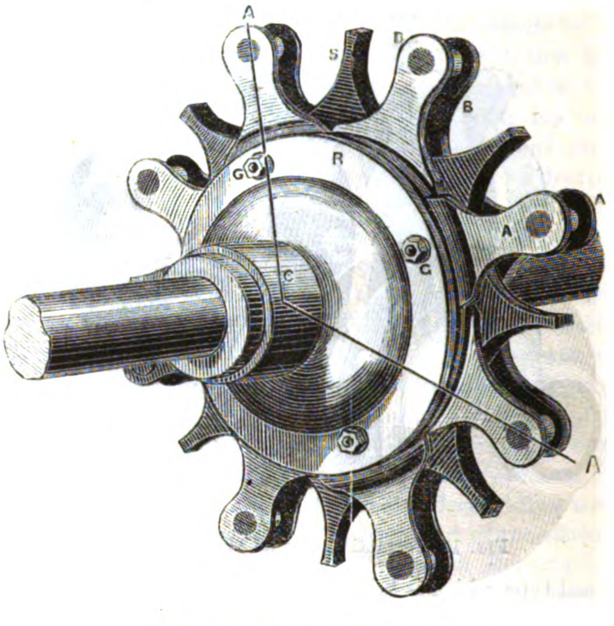

FIG. 7.—Centre Boss of Armature.

briefly called the starpiece. The middle convolution on the right of the figure shows T, the beginning of one strip, and M, the end of a strip. Tracing the white line from T to TTT, it will be found to pass from the inside to the No. 2 strip; at the second bend from the starting point, and after

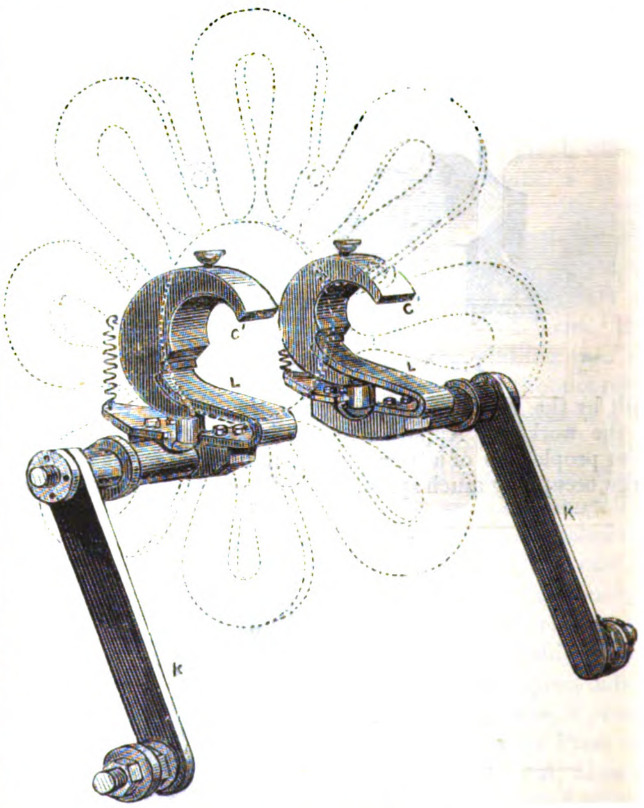

FIG. 8.—Collectors.

another similar interval, it becomes No. 3 strip, and finally the outside strip, being connected to the rivet M. In this figure the rivets M M are those connected to the collecting ring, while those indicated by N N are insulated. H H indicate the bolt holes, and S is placed where the hole for the

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shaft has to be cut. X X indicates insulation, which again should be indicated in the bend where are the insulated rivets N N. The armature in Fig. 5 is shown separately; it is 30in. in diameter. Fig. 6 is a section through what may be termed the rubber boss. The top rivet in this drawing corresponds to M in Fig. 4, while the lower rivet corresponds to N in Fig. 4. The outer boss A is insulated, as shown at F F, by vulcanised fibre, and is connected by means of the rivet M to the ferrule at the end of the copper strip. A is, however, connected by the bolt G to the collector ring R C. The collector ring is insulated from the shaft by two rings of papier maché, held in position by screws encircling the shaft. Looking at the lower parts, the other end of the strip is connected to the starpiece S, and through the bolt G, which screws into S to the other collector ring. The inner boss B B is split, and slips into a feather key for ease in construction. We have thus traced the path of the current generated from the beginning of a copper strip to the collector ring. The armature of the thousand light machine is made of three copper strips, two of which are

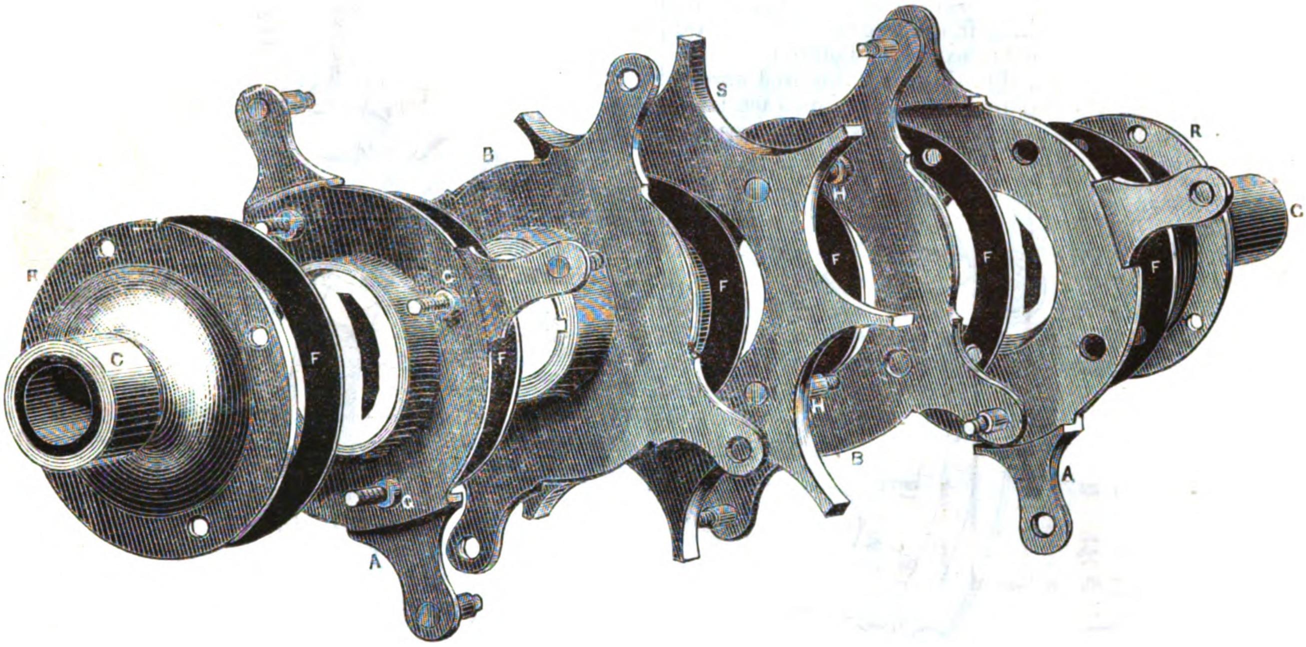


Fig. 9.—Expanded Boss.

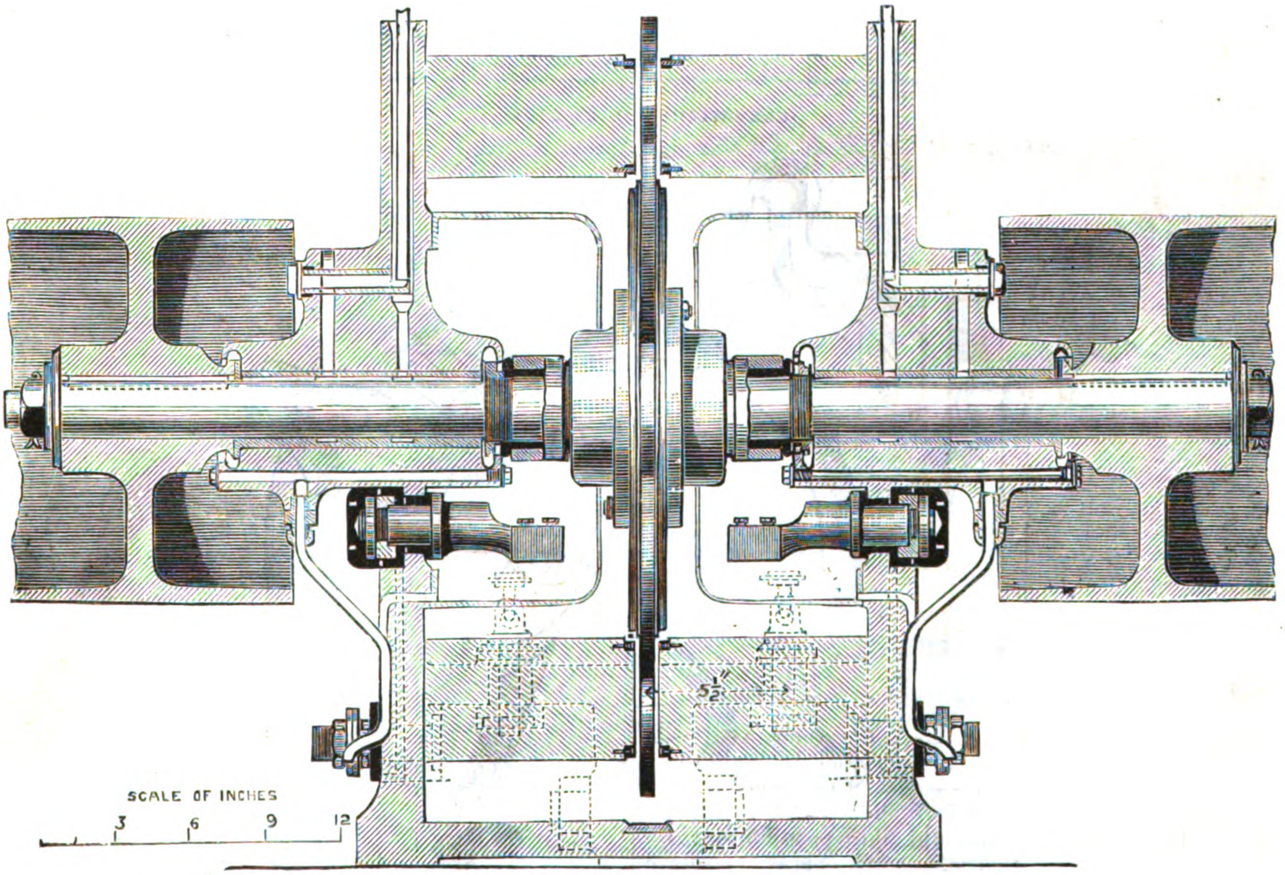
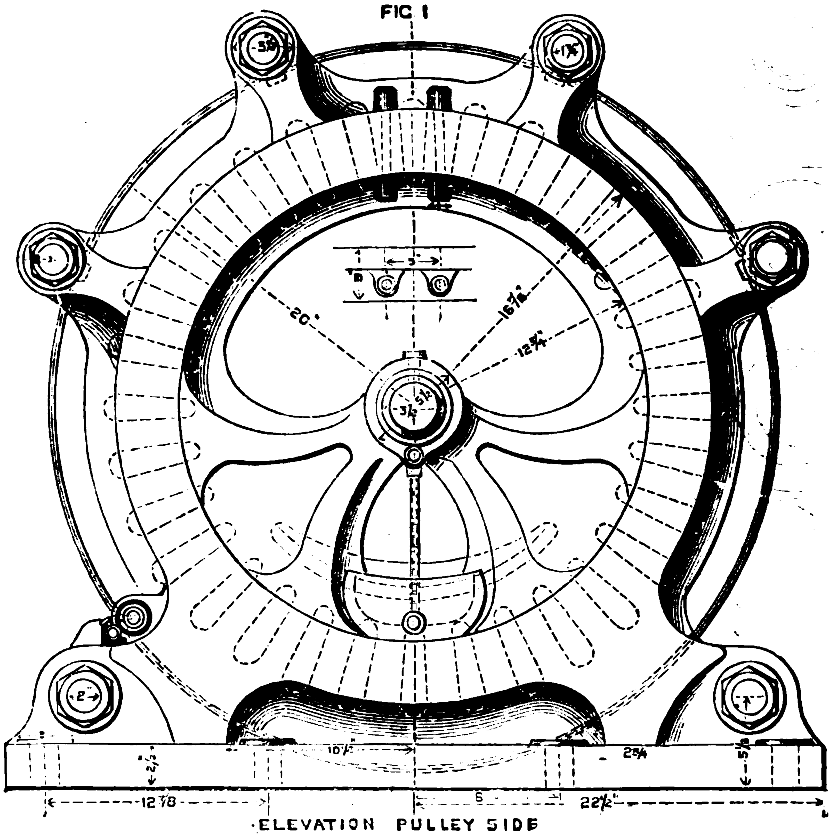


Fig. 10.—Section of Machine.

·75in. wide and 1·5mm. thick, while the third is 1·75mm. thick, the total depth of copper thus being 4·75mm. Each strip is separated by ·02in. strips of fibre. The length of each strip is 13ft. 10in., and as each strip makes 10 turns there are altogether 30 layers. The total weight of the armature is 3qr. 12lb., of which the starpiece weighs 11lb. The resistance is given at ·005 ohm. Fig. 7 shows the centre boss of armature. Fig. 8 shows the collectors. The diameter of the collecting rings is 4in. and width 2in. The collectors C′ C′ cover, or rather, we should say, bear upon about a semi-circle of the ring. They are 2in. wide, and fastened by universal joints, to allow of facility of motion, and to adjust themselves to inequalities of shaft. Each collector is provided with a spring, which counteracts the tendency to forward motion because of the rotation of the shaft keeping the position of the collectors constant. In order to ensure good conduction the collectors are connected by strips of copper 38mm. by 25mm., forming altogether strips 2in. by ⅝in. to a copper bar 1·5in. diameter, and hence to strip V 2·5in. by ·5in. and terminals.

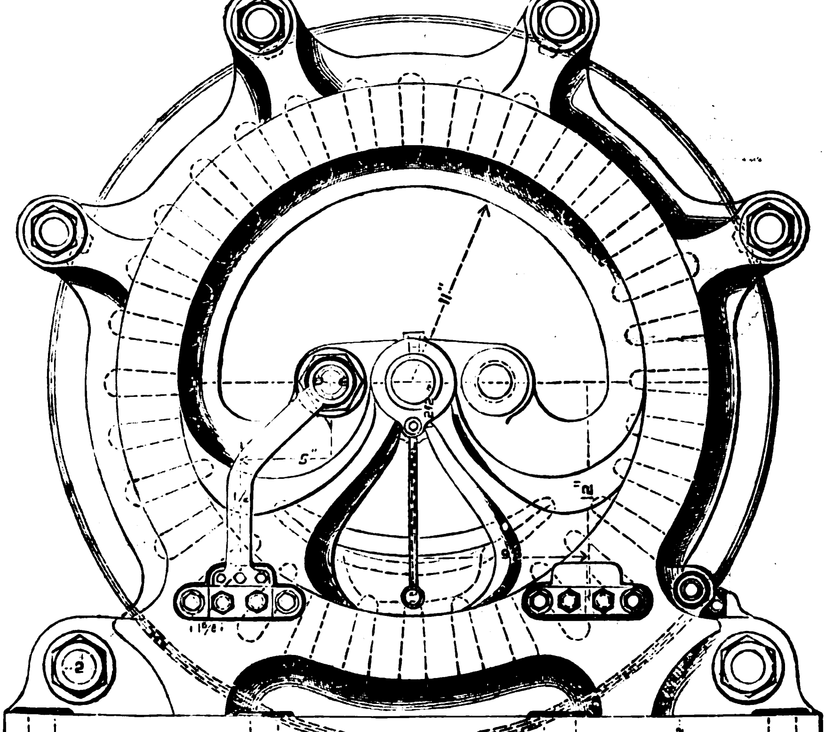
SLOW-SPEED MACHINE.

FIG 1



ELEVATION PULLEY SIDE

FIG. 2



ELEVATION COLLECTOR SIDE

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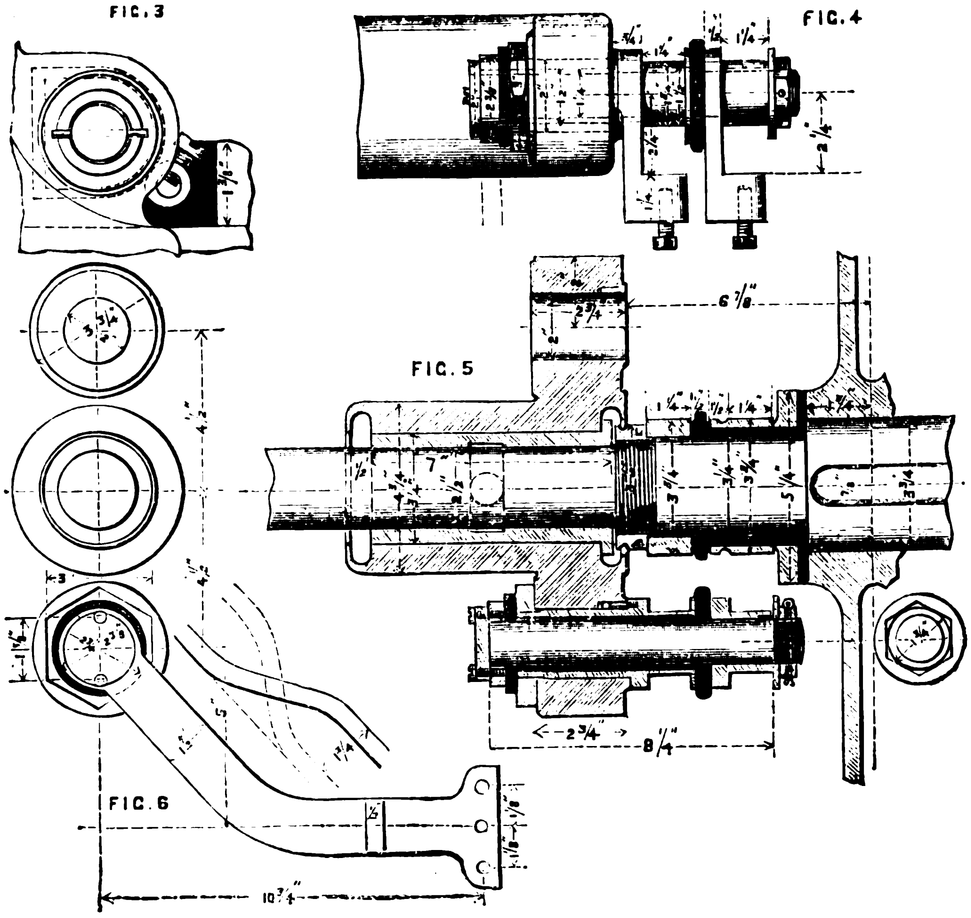
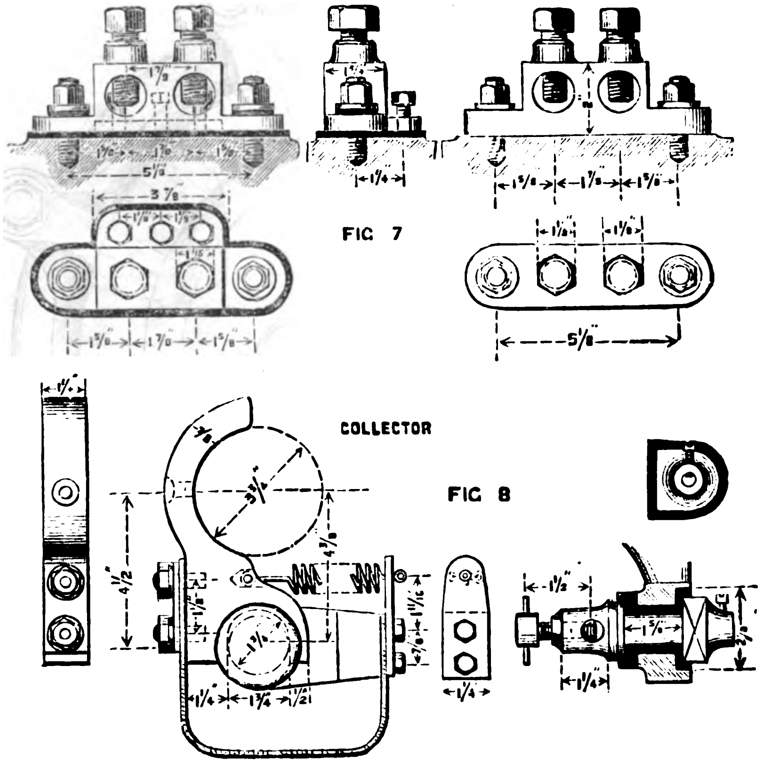
Fig. 9 shows various important parts of the boss in an expanded form. S is the starpiece upon which the armature is wound, B B the inner boss with rivets N insulated, A A the outer boss with rivet M connected, as explained above; C C, R R, the collector rings and connections; the whole held together by rivets in A and B and bolts G. Here, as elsewhere, F F shows the vulcanised fibre for insulation. At the end of the shaft is a screw pressing insulation against C, and keeping the whole in position. The two upper bolts holding the machine together are 1·5in. diameter, the two lower being 1·75in. diameter. The total weight of the machine is 32 cwt.



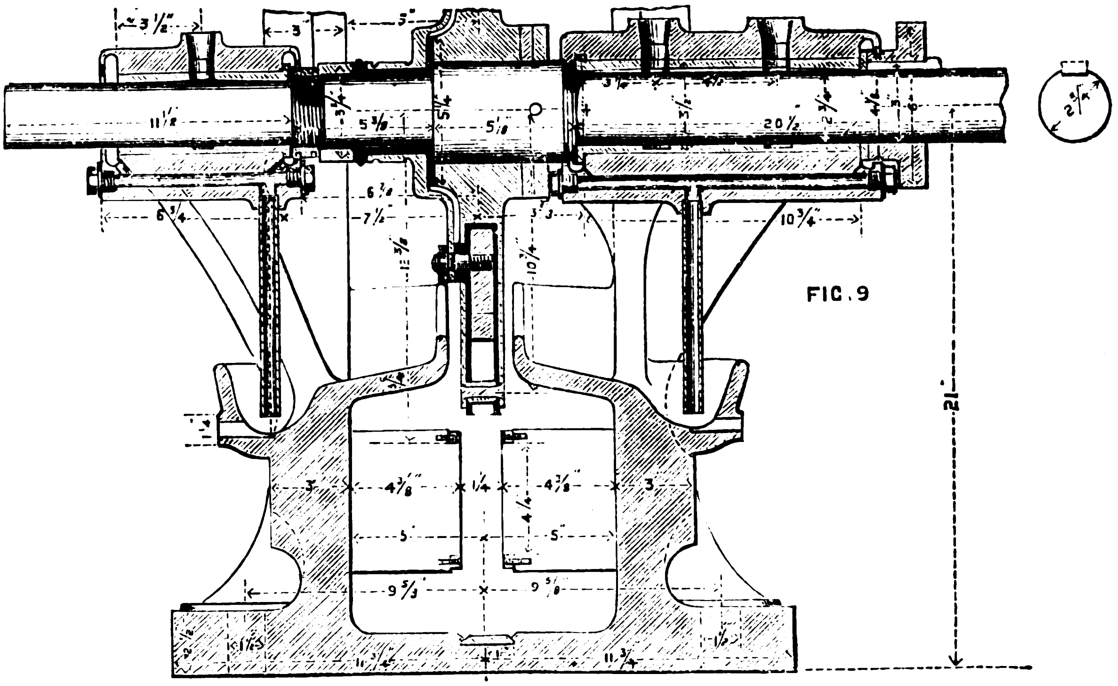
Details of Ferranti Slow-speed Machine.



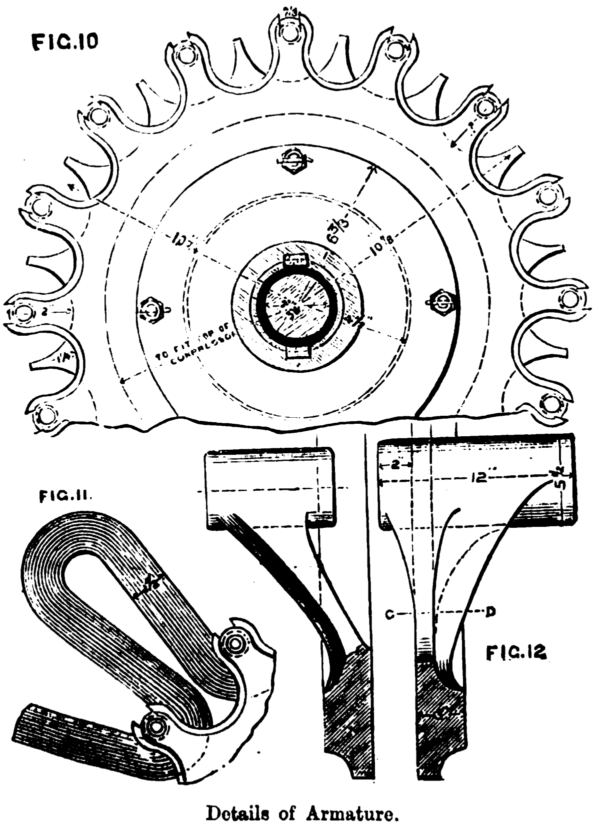
Details of Collector, &c., of Slow-Speed Machine.

In the section shown in Fig. 10 we see the lubricating arrangements of the machine. In the carcass we find two holes bored, one on either side; these lead to channels for lubricating the bearing, each bearing having two channels, one being near the pulley, and the other near the armature. The one near the armature is simply a continuation of the holes first mentioned, but of rather smaller diameter. It is tube to pass through. One wick is put into the tube, and another between it and the hole, thus allowing the bearing to be well lubricated, and enabling either end to be cooled if heated. The oil runs out of the bearing at both ends into a sort of cup, whence it is taken off by a couple of copper tubes, one of which is shown in the drawing.

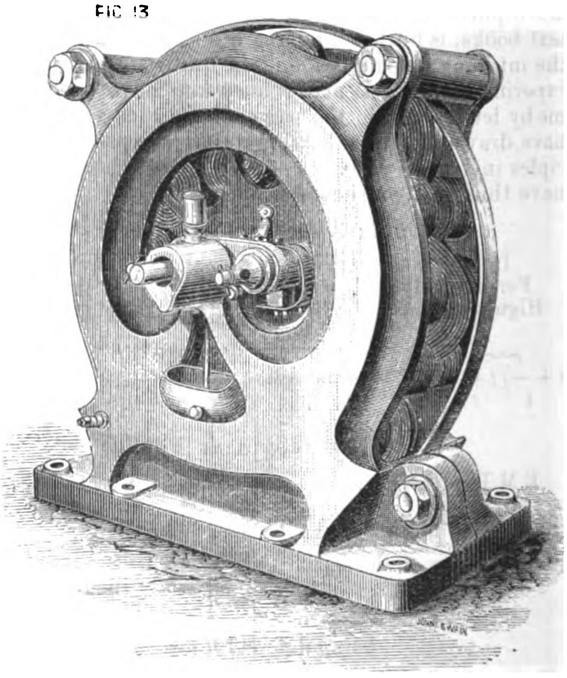
We have a number of figures supplied by Mr Belfield re-



Section Lower Part of Machine.



Details of Armature.



Ferranti Ship Machine.

tapped and takes a copper tube which projects above the body of the machine, leaving a space between it and the inside of the hole, so that any oil running between the tube and the holes will go to the pulley side of the bearings, while any oil going inside the tube will flow to the armature side. The oil cup fits into the hole, which is slightly tapered to receive it, and allows the lating to the trial on October 17, but it will be unnecessary to enter into details as to resistance of circuit, because, being only temporary, it would differ somewhat from that of a permanent and carefully made installation, and we hope to give the figures relating to the permanent installation. A number of sets of diagrams were taken from the engine used—one by Fowler, of Leeds—and those taken independently bear

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out the calculations made by Mr. Belfield, that the total h.-p. developed by the engine was about 123·1 h.-p. Of this some 40·7 h.-p. was absorbed elsewhere than in the dynamo, leaving 82·4 h.-p. to be absorbed by the dynamo. The lamps used were Swan 20 c.-p. 100 volt lamps (nominal). For absolute measurements it would be necessary to have photometric tests, but the general opinion was that the lamps were giving nearly or quite their normal light. Altogether the trial was very satisfactory, and great interest will be felt in the result obtained by the machine in the permanent installation.

The normal number of revolutions of the machine described to produce the required E.M.F. and current, is about 1,400, and this has been thought too great. A machine has therefore been designed to run at a considerably less speed to obtain given results. This we will call the slow-speed machine, and is intended to run at about 300 revolutions per minute, and to give current for 500 Swan lamps. It is really designed to be used on board ship. Figures 1 and 2 show side views of this machine, while Figs. 3, 4, 5, and 6 show details, the uses of which parts will be recognised from the description of the various parts of the thousand light machine. Figs 7 and 8 show the details of the collector rings, collectors, and terminals. Fig. 9 is a section of the lower half of the machine, the upper half, of course, being similar in all respects. Figs. 10, 11, and 12 show details connected with the armature and starpieces, while Fig. 13 shows the whole machine. It may be noticed that this slow-speed ship machine is about the same size as the three thousand five hundred light fast speed machine. In the slow-speed machine the magnets are much shorter, the diameter of the armature being increased to obtain the required periphery velocity to cut the line of force with the speed necessary to get the requisite E.M.F.

THE COMBINATION OF CELLS INTO BATTERIES.

BY J. T. SPRAGUE.

This is a matter on which learners in electricity are often much puzzled, and the explanation of which, as given in most text books, is buried under a crowd of symbols based upon the internal resistances, and is quite unintelligible to many experimenters. As many questions have been addressed to me by letters and in the pages of various scientific papers, I have drawn up the following tabular expression of the principles involved, which appears to meet the difficulties which have thus been presented to me :—

COUPLING OF CELLS IN BATTERIES.

In *series*. For intensity. High resistance.	*Circuits.*	*Parallel* or *multiple arc*. For quantity. Low resistance.
(+ −) (+ −) (+ −) (cells 1, 2, 3)	*Connections.*	A: {(+ −), (+ −), (+ −)} or B: {(+ −)(+ −), (+ −)(+ −)} (1, 2)

ELECTROMOTIVE FORCES.

E.M.F. of 1 + 2 + 3	are as	That 1 cell in A. of 1 + 2 in B.

RESISTANCES.

Sum of those of the separate cells.	are as	The reciprocal of the sum of the reciprocals of those of the cells in arc.

Using different kinds of cells.

Various kinds may be used together, but all should have equal capacity for current.	Cells must be equal in E.M.F., but may be of different resistances or capacities. Each series must be of equal E.M.F.

Capacities of cells.

All should be so balanced that they will work together, and not allow *some to be exhausted* before the others.

The same principles apply to secondary batteries.

ON PATENTS FOR INCANDESCENT LAMPS.

BY C. A. STEPHENSON.

(CONCLUDED FROM PAGE 550.)

It seems to be generally known that a great proportion of patents are valueless for want of novelty, but it would be very unfair to patentees as a body if it were taken for granted that they are aware of the fact as regards their own patents. Although a great deal has been done of late towards completing the indexes in the Patent Office, it still requires a very considerable amount of patient research to ascertain with certainty whether any particular point has been patented. An inventor as a rule goes to a patent agent, who does not consider it as part of his business to ascertain exactly what are the really novel points in the invention. The inventor is equally ignorant. The two between them draw up the specification. The general result is that, provided there is anything in the patent worth contesting, the rather expensive process of disclaiming has to be gone through sometimes as often as four times. If a tithe of the cost of taking out disclaimers was to be spent in searching at the Patent Office before any patent specification was drawn up, the result would be most beneficial to honest inventors. But to return to incandescent lamps; before the new era of invention set in in 1878 lamps had been made with carbon filaments of the horseshoe shape to turn in vacuum. The patents, therefore, which present any novelty are more for improvements than for actual inventions of lamps. In the following table I have summarised the main points of improvement, giving the dates and the names of the patentees.

TABLE SHOWING MAIN HEADS OF IMPROVEMENTS IN INCANDESCENT LAMPS SINCE 1878.

Name of Inventor.	Nature of Invention or Improvement.	Date.	No. of Patent.	Remarks.
Lane-Fox..	"High resistance"	1878	3988	Incidentally ment'd, not claimed.
Sawyer ...	Flashing	1878	4847	Claimed.
Sawyer ...	Expelling gas from a filament by heating it when in a globe containing a carbon preservative atmosphere, and continuing the process of forcing a fresh carbon preservative atmosphere into the globe till the filament is freed from all gas	1878	4847	Claimed.
Lane-Fox.	Sealing in by clamping the stem of the glass bulb on to the conducting wires............	1879	1122	Provisional patent only. Void.
Edison ...	Expelling gas from a filament by heating it when in a globe from which the air has been exhausted, and continuing the process of exhausting till the filament is freed from all gas...	1879	2402	Claimed.
Edison ...	Mould for carbonising a whole substance	1879	5127	Claimed.
Swan ...	Baking filaments in powdered charcoal or carbon..............	1880	250	Claimed.
Swan	Parchmandising material from which filaments are to be made before process of baking	1880	250	Claimed.
Lane-Fox..	Baking filaments on a block...	1881	225	Claimed.
Edison ..	Joining filament and wire by process of electro-plating......	1881	768	Clam'd. One disclaimer taken out 12th July, 1882.

This list is not of very formidable dimensions. The fact is that the greater number of patents are re-inventions of methods already known, or at best but modifications of previous patents. The real improvements are for the most part in those details of manufacture which experience alone can give, and the experience that has been gained is no doubt in many cases of far greater value than any patents.

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OVERHEAD WIRES AGAIN.

The accident which happened to one of their wires in the heart of the city of London on Saturday last will, it may be feared, only confirm the telephone companies in the arrogant attitude which has provoked so much angry comment of late. That an iron wire of considerable length may, if it chance to be a telephone wire, be shot from the housetops, violently sweeping the crowded thoroughfare below, and yet do no more damage than might be inflicted with a carter's whip, is enough to inspire the most timid with confidence, and to vastly augment the insolence of its proprietors. As an evening contemporary, commenting on the incident at the time, remarked, somebody will have to be killed—a bishop by preference—before any serious notice will be taken of this public danger. The persons, however, to whom such serious notice would be most unwelcome argue meanwhile that they are public benefactors, that they hold a sort of commission from on high to do what seemeth them best, and to do it in any manner the inspiration of their emissaries may prompt. One of these latter, it is true, seems to have faltered in his mission for a moment, and even threw his rod, so to speak, at the heads of the multitude; but it only hit an old woman, who did not happen to be a bishop, and things go on as beneficently as before. Naturally the benefactors are quietly jubilant, and the newspapers a little vexed at this tame conclusion of so promising a topic.

This, however, is by no means the first or the worst accident of the kind that has yet occurred, and we may safely assert that will not be the last. The limit of strength and the period of durability are very easily overstepped in matters of this kind, and it is too much to expect that there will be caution in these respects where there has been neither foresight nor scruple in others. The danger of overhead wires in inhabited places is admitted on all hands; breakage is common on the high roads and on railways, where the spans are shorter and supervision easier and more constant. The extraordinary increase latterly of such wires in towns is due almost exclusively to the telephone system, and the danger is all the greater, though perhaps not so imminent, because, compared with the telegraphs, the telephone system is new, and therefore comparatively safe while the newness lasts. It is in this stage that reckless additions are being made, in some obvious instances exceeding the limits of safety even now, and insuring disaster when time and the elements apply their uncompromising tests at no distant date. It was not so much as a warning against immediate danger as in deprecation of deliberate risk that we joined in protesting against the inordinate multiplication of overhead wires. And this risk is not to life and limb alone, but to the capital expended on the erections. We argue that, sooner or later—and at the present rate of increase very soon—they will be stopped by compulsion, if not by disaster.

And this aspect of the case, duly considered, is sufficient answer to our respected correspondent, whose letter in defence of the companies we published in our last issue. It is idle to argue on the admitted fact that the Government own some of the wires which cross the streets of most of our great towns. They are confessedly few; it was never contemplated largely increasing their numbers, and when the necessity arose for doing that, steps were taken to carry future wires underground. Economy has influenced the Government in this matter more perhaps than we could wish, and its underground telegraph system is not so general as it ought to be. But it has recognised the demerits of the overhead system, and it has proved the underground system to be practicable and efficient. Their warmest friends cannot say this much for the companies, who in fact have done the exact opposite, acting as if their system could be multiplied indefinitely, and public opinion, as well as public safety, defied for ever. Moreover, they have steadily asserted that telephone wires cannot be carried underground. What we said about governmental management was in no way directed to its monopolising tendencies. That is a separate question, about which we have already expressed our opinion on fitting occasion. What we asserted, and what we reiterate now, is that, whilst the monopolists in this instance have shown wisdom and foresight, the competitive systems have shown none, and that the only explanation is to be seen in the fact that the latter work solely for immediate profit and the other does not. This explanation applies to the railways, which for absence of method and extravagant outlay were, and to a large extent still are, a standing warning against incoherent enterprises and ill-regulated competition.

Our correspondent makes a good point, however, of the Postmaster-General's action against a suburban vestry for refusing to let him carry a wire, or wires, across some portion of their district; and it is even urged that so long as a Government department owns a single overhead wire in towns the development of overhead wires by its rivals ought not to be interrupted.

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We may safely leave this last argument to the common sense of any vestry or jury; but as touching the special instance cited, we consider it a most regretable incident. Whatever justification for it may be found in the local circumstances, it is perfectly astounding that just now, when public opinion is growing strongly against the nuisance, a public department should appear in the character of defender and promoter of overhead wires opposed to the will of the local inhabitants. If economy alone is to be sole arbiter wherever fresh wires have to be laid for the reduced tariff next year, then indeed the telephone companies will have a good defence behind the broad back of their official rival. We trust, however, that the Wandsworth case is an exception and not an example, and in that case even the trivial accident in Gresham-street will not have happened in vain.

ON TELPHERAGE.*

BY PROFESSOR FLEEMING JENKIN, LLD., F.R.S.

"The transmission of vehicles by electricity to a distance, independently of any control exercised from the vehicle, I will call Telpherage." These words are quoted from my first patent relating to this subject. The word should, by the ordinary rules of derivation, be telephorage, but as this word sounds badly to my ear, I ventured to adopt such a modified form as constant usage in England for a few centuries might have produced, and I was the more ready to trust to my ear in the matter, because the word telpher relieves us from the confusion which might arise between telephore and telephone when written.

I have been encouraged to choose telpherage as the subject of my address by the fact that a public exhibition of a telpher line, with trains running on it, will be made this afternoon for the first time.

You are, of course, all aware that electrical railways have been run, and are running with success in several places. Their introduction has been chiefly due to the energy and invention of Messrs. Siemens. I do not doubt of their success and great extension in the future—but when considering the earliest examples of these railways in the spring of last year, it occurred to me that in simply adapting electric motors to the old form of railway and rolling stock, inventors had not gone far enough back. George Stephenson said that the railway and locomotive were two parts of one machine, and the inference seemed to follow that when electric motors were to be employed a new form of road and a new type of train would be desirable.

When using steam we can produce the power most economically in large engines, and we can control the power most effectually and most cheaply when so produced. A separate steam engine to each carriage, with its own stoker and driver, could not compete with the large locomotive and heavy train; but these imply a strong and costly road and permanent way. No mechanical method of distributing power, so as to pull trains along at a distance from a stationary engine, has been successful on our railways; but now that electricity has given us new and unrivalled means for the distribution of power, the problem requires reconsideration.

With the help of an electric current as the transmitter of power, we can draw off, as it were, one, two, or three horse-power from a hundred different points of a conductor many miles long, with as much ease as we can obtain 100 or 200 horse-power at any one point. We can cut off the power from any single motor by the mere break of contact between two pieces of metal; we can restore the power by merely letting the two pieces of metal touch; we can make these changes by electro-magnets with the rapidity of thought, and we can deal as we please with each of one hundred motors without sensibly affecting the others. These considerations led me to conclude, in the first place, that when using electricity, we might with advantage subdivide the weight to be carried, distributing the load among many light vehicles following each other in an almost continuous stream, instead of concentrating the load in heavy trains widely spaced, as in our actual railways. The change in the distribution of the load would allow us to adopt a cheap, light form of road. The wide distribution of weight entails many small trains in substitution for a single heavy train; these small trains could not be economically run if a separate driver were required for each. But, as I have already pointed out, electricity not only facilitates the distribution of power, but gives a ready means of controlling that power. Our light, continuous stream of trains can, therefore, be worked automatically, or managed independently of any guard or driver accompanying the train —in other words, I could arrange a self-acting block, preventing collisions. Next came the question, What would be the best form of substructure for the new mode of conveyance? Suspended rods or ropes, at a considerable height, appeared to me to have great advantages over any road on the level of the ground; the suspended rods also seemed superior to any stiff form of rail or girder supported at a height. The insulation of ropes with few supports would be easy; they could cross the country with no bridges or earthworks; they would remove the electrical conductor to a safe distance from men and cattle; cheap small rods employed as so many light suspension bridges would support in the aggregate a large weight. Moreover, I considered that a single rod or rail would present great advantages over any double rail system, provided any suitable means could be devised for driving a train along a single track. [Up to that time two conductors had invariably been used.] It also seemed desirable that the metal rod bearing the train should also convey the current driving it. Lines such as I contemplated would not impede cultivation nor interfere with fencing. Ground need not be purchased for their erection. Mere wayleaves would be sufficient, as in the case of telegraphs. My ideas had reached this point in the spring of 1882, and I had devised some means for carrying them into effect when I read the account of the electrical railway exhibited by Professors Ayrton and Perry. In connection with this railway they had contrived means rendering the control of the vehicles independent of the action of the guard or driver; and this absolute block, as they called their system, seemed to me all that was required to enable me at once to carry out my idea of a continuous stream of light, evenly-spaced trains, with no drivers or guards. I saw, moreover, that the development of the system I had in view would be a severe tax on my time and energy; also that in Edinburgh I was not well placed for pushing such a scheme, and I had formed a high opinion of the value of the assistance which Professors Ayrton and Perry could give in designs and inventions.

Moved by these considerations, I wrote asking Professor Ayrton to co-operate in the development of my scheme, and suggesting that he should join with me in taking out my first Telpher patent. It has been found more convenient to keep our several patents distinct, but my letter ultimately led to the formation of the Telpherage Company (Limited), in which Professor Ayrton, Professor Perry, and I have equal interests. This company owns all our inventions in respect of electric locomotion, and the line shown in action to-day has been erected by this company on the estate of the chairman—Mr. Marlborough R. Pryor, of Weston. Since the summer of last year, and more especially since the formation of the company this spring, much time and thought has been spent in elaborating details. We are still far from the end of our work, and it is highly probable what has been done will change rapidly by a natural process of evolution. Nevertheless, the actual line now working does in all its main features accurately reproduce my first conception, and the general principles I have just laid down will, I think, remain true, however great the change in details may be.

The line at Weston consists of a series of posts, 60ft. apart, with two lines of rods or ropes, supported by crossheads on the posts. Each of these lines carries a train; one in fact is the up line, and the other the down line. Square steel rods, round steel rods, and steel wire ropes are all in course of

* Introductory address delivered to the Class of Engineering, University of Edinburgh, October 30, 1883.

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trial. The round steel rod is my favourite road at present. The line is divided into sections of 120ft. or two spans, and each section is insulated from its neighbour. The rod or rope is at the posts supported by cast-iron saddles, curved in a vertical plane, so as to facilitate the passage of the wheels over the point of support. Each alternate section is insulated from the ground; all the insulated sections are in electrical connection with one another—so are all the uninsulated sections. The train is 120ft. long—the same length as that of a section. It consists of a series of seven buckets and a locomotive, evenly spaced with ash distance pieces—each bucket will convey, as a useful load, about $2\frac{1}{2}$ cwts., and the bucket or skep, as it has come to be called, weighs, with its load, about 3 cwts. The locomotive also weighs about 3 cwts. The skeps hang below the line from one or from two V wheels, supported by arms which project out sideways so as to clear the supports at the posts; the motor or dynamo on the locomotive is also below the line. It is supported on two broad flat wheels, and is driven by two horizontal gripping wheels; the connection of these with the motor is made by a new kind of frictional gear which I have called nest gear, but which I cannot describe to-day. The motor on the locomotive will give as a maximum $1\frac{1}{2}$ horse-power when so much is needed. A wire connects one pole of the motor with the leading wheel of the train, and a second wire connects the other pole with the trailing wheel; the other wheels are insulated from each other. Thus the train, wherever it stands, bridges a gap separating the insulated from the uninsulated section. The insulated sections are supplied with electricity from a dynamo driven by a stationary engine, and the current passing from the insulated section to the uninsulated section through the motor drives the locomotive. The actual line is quite short, and can only show two trains, one on the up and one on the down line; but with sufficient power at the station any number of trains could be driven in a continuous stream on each line. The appearance is that of a line of buckets running along a single telegraph wire of large size. A block system is devised and partly made, but is not yet erected. It differs from the earlier proposals in having no working parts on the line. This system of propulsion is called by us the Cross Over Parallel Arc. Other systems of supplying the currents, devised both by Professors Ayrton and Perry and myself, will be tried on lines now being erected; but that just described gives good results. The motors employed in the locomotives were invented by Messrs. Ayrton and Perry. They are believed to have the special advantage of giving a larger power for a given weight than any others. One weighing 99lb. gave $1\frac{1}{2}$ h.-p. in some tests lately made. One weighing 36lb. gave 0·41 h.-p.

No scientific experiments have yet been made on the working of the line, and matters are not yet ripe for this—but we know that we can erect a cheap and simple permanent way, which will convey a useful load of say 15 cwts. on every alternate span of 120ft. This corresponds to $16\frac{1}{2}$ tons per mile, which, running at five miles per hour, would convey $92\frac{1}{2}$ tons of goods per hour. Thus, if we work for twenty hours, the line will convey 1850 tons of goods each way per diem, which seems a very fair performance for an inch rope. The arrangement of the line with only one rod instead of two rails diminishes friction very greatly. The carriages run as light as bicycles. The same peculiarity allows very sharp curves to be taken, but I am without experimental tests as yet of the limit in this respect. Further, we now know that we can insulate the line satisfactorily, even if very high potentials came to be employed. The grip of the locomotive is admirable and almost frictionless, the gear is silent and runs very easily. It is suited for the highest speeds, and this is very necessary, as the motors may, with advantage, run at 2,000 revolutions per minute.

The suspended rods are not suitable for high speeds. Centrifugal force would use great strains on them, and the vehicles would be shot up into the air at the points of support. Very high speeds might be attained for light trains with a stiff road, but we are for the present less interested in this application of our ideas. A smaller type of line with $\frac{5}{8}$ rods and smaller spans is in course of construction. This will probably soon be extended for a mile or so, now that we have gained some experience on the few spans of this heavier line.

At present we do not contemplate working lines extending more than five miles from a station, so that in a long continuous line we should require stations at intervals of ten miles. A single station could work, either simultaneously or in succession, a large number of lines radiating from it in many directions.

I cannot yet enter into questions of cost, and the company is hardly ready to undertake contracts, except perhaps for very simple cases. We have still to elaborate designs for sidings; for loading and marshalling the trains; and we have still to test the arrangements for governing and blocking. We have also to compare different systems of electric propulsion and blocking, and improve the design of many details in construction. All this will take time, but time and thought are all that is required. No new discovery is wanted; no unforeseen difficulty has been met with.

I am almost afraid to speak of the probable uses to which telpherage may be put. If I said all I thought, I should be told I was describing an electrical Utopia. The first and most obvious use of a telpher line is that to which existing wire tramways are already put—namely, the conveyance of minerals or ore from mines to canals, railways, or the sea. The suspended wire rope is specially suited for rocky uneven ground, and very heavy gradients could be worked. The telpher line has the following advantages over the present system:—It can go round sharp curves, change the gradient as often as is desired, and be made of any length; any train can be stopped and shunted without stopping the others. If made with no working parts, as in the present example, the permanent way may be left idle for part of the year with no sensible deterioration.

Mineral traffic of this kind is, however, in my opinion, only one small part of the work which these lines can do. Where railways and canals do not exist, telpher lines will provide the cheapest mode of inland conveyance for all goods—such as corn, coal, root crops, herrings, salt, bricks, hides, and so forth—which can be conveniently subdivided into parcels of one, two, or three hundredweight. In new colonies the lines will often be cheaper to make than roads, and will convey goods far more cheaply. In war they will give a ready means of sending supplies to the front. Moreover, wherever a telpher line exists, power is thereby laid on, and this power may be used for other purposes than locomotion—a flexible wire attached to the line will serve to drive a one, two, or three horse engine, which may be used for any imaginable purpose, such as digging, mowing, threshing, or sawing. It is true that in the transmission of the power more than half may be wasted; but the proportion wasted is diminishing yearly, monthly, almost daily, with the growth of our electrical knowledge; and when we remember that by stationary engines in London power can be produced at the rate of about one halfpenny per hour for each effective horse we shall not be alarmed at the prospect of doubling this cost when the power is delivered on a rough hillside, especially when we remember that the engine receiving that horse-power need weigh no more than one hundred pounds. Surely I am not too sanguine in expecting that great changes will be produced in agriculture by these new facilities for transport, coupled with the delivery of power at will from any point of the telpher road. It must not be supposed that I look on the new telpher lines as likely to compete with railways or injure their traffic. On the contrary, my feeling is that they will act as feeders of great value to the railways, extending into districts which could not support the cost even of the lightest railway. It is idle to endeavour to foretell the future of any new idea, but this much is certain—a novel mode of transport offering some exceptional adva-tages will be publicly shown on a practical scale to-day.

Before concluding I may, perhaps, be allowed to say that it has been a great pleasure to me to receive much practical assistance from old students of this class.

The cross-over system of propulsion is in part due to Mr. Archibald Elliott, a medallist here, who further gave me valuable assistance last year. The actual line has been

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designed and erected under the superintendence of Mr. A. C. Jameson, a distinguished student, and for some time my assistant in this class. Mr. H. C. Mylne, another student, is working with good effect at many details, and I owe to my second son, C. Frewen Jenkin, also a good student, the first idea of that modification of nest-gearing by which the rope is gripped; and since I mention these gentlemen, I can hardly refrain from speaking of other students who have so admirably helped me in connection with sanitation. First, Mr. Alexander Welsh, to whom is due in very great measure the success of those Sanitary Protection Associations which are now found in eight large towns. Mr. Fleming, Mr. Gilbert Thomson, and Mr. James Thomson, all distinguished students, are working admirably in connection with these associations. I will further claim all teachers of engineering as my fellow-workers, in order that I may speak of the great pleasure it gives me to think that the first medallist of this class, Mr. R. H. Smith, is Professor of Engineering in Josiah Mason's College in Birmingham, and that my friend, Mr. James Alfred Ewing, who was, I think, our youngest medallist, is now Professor of Engineering in Dundee. Although, no doubt, in all these cases, as in the case of numerous other successful men who have passed through this class, the success is certainly due to the character of the student far more than any teaching given here, nevertheless, I may be pardoned if I believe that there is some evidence to show that the endowment of this chair by Sir David Baxter has been followed by good results.

Let it be our endeavour, gentlemen, to add to those results.

RONALDS AND HIS ARM CHAIR.

Mr. A. J. Frost has forwarded us the following curious scrap which he has found amongst the unpublished MSS. of the late Sir Francis Ronalds, in the library of the Society of Telegraph Engineers and Electricians. It is the first of a series of letters, describing very graphically his wanderings in Europe and Egypt two years after his unsuccessful attempt to interest the British Government in his Electrical Telegraph:—

"My Dear Arm Chair: "Dover, Sept. 1, 1818.

"Although I have at length carried into effect my so long premeditated and often repeated threat of tearing myself from your enervating society, of flying your luxurious arms, I cannot anticipate the long period of our separation without compassionating your forlorn state during my absence. Alas, poor fellow, you must now mope in a corner of the study, unoccupied and unheeded; or, like many a *protegé* forsaken by his protector, noticed only to be insulted. They will make use of you only when shoes are to be tied, cloaks and bonnets deposited, and for all sorts of degrading purposes, and the slut of a housemaid will scarcely deign to bestow upon you a single flap of her dirty duster. You will even be worse conditioned than your brethren. Yet it must be so. Too long have your seductive charms been employed to induce a train of old bachelor-like grievances, which can only be removed by a removal from you, and by seeking in the wide World new and more active occupation. I will not upbraid you, perhaps we are both equally culpable. We part in peace, in one short hour I quit old England to wander I scarcely know whither, and to return I scarcely know when, but certainly not until I have satiated my curiosity in many considerable parts of Europe, or perhaps I may take a still wider range. I propose for the sake of my own amusement and your consolation to keep a kind of diary in the form of letters *to you*, because we are on such terms. You know that I need not fear your critiques, your compliments, nor your complaints of its dulness or frivolity, or want of plan. I will not put down *more* than I can help of what has been said over and over again a hundred times by travellers, nor will I venture one word of classical criticism, for our studies have been scarcely ever directed to that branch of literature, you know, but you must still expect much stale news, common place reasoning, and ill-directed observation. Fare as well as you can dear chair, and believe that I still remain your affectionate master and friend, F. R."

CORRESPONDENCE.

ANIMAL MAGNETISM.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I have received the following private letter from Prof. M'Kendrick, which he has given me full permission to publish *in extenso*, as it expresses shortly his position:—

"33, Westbourne-gardens, Glasgow,
Oct. 18, 1883.

"Dear Sir: Accept my thanks for the copy of *The Electrician*, which reached me a day or two ago. At present I am too busy with examination work at the University to find time to discuss the question at issue. Nor do I think any good would come from such a public discussion as you desire. My position is that after long inquiry I have completely failed in observing any change in vital phenomena in very strong magnetic fields, and that attempts to influence vital phenomena by comparatively weak magnets outside the body have no rational basis, are futile, and play into the hands of quacks and charlatans. I am not aware of any observations as to the effect of magnets on vital phenomena which may not be accounted for without the assumption that any physical influence has been exerted.

"It rests with you and with those who hold your views to show even one authentic instance of any vital phenomenon being influenced by magnetic action. If you can show this, it would be a real step in science. Until this has been done, speculative opinions as to possible actions of the earth's magnetism are of little value, and I contend that practical attempts to influence the body by magnets, founded on these speculative opinions, have no rational basis.—Yours, &c.,

"Dr. Shettle." "John G. M'Kendrick.

I do not desire to disturb the routine of work to which the Professor is pledged; nevertheless, I trust you will find space for another letter in *The Electrician* in further corroboration of the conclusion I have already advanced, as, in my judgment, the interests of the general community are too largely associated with the collaterals of the subject to justify the question being left in doubt, the more especially as the conclusions which I have ventured to put forth are not advanced as a theory only, but as a compilation of facts from a careful consideration of the laws of nature. I feel the more emboldened to take this course as I am told that it rests with me, and those who hold my views, to show even one authentic instance of any vital phenomenon being influenced by magnetic action.

Some two hundred years ago Galileo astonished the world by his statement that the earth moved. Allow me to ask the question whether he was called upon to prove such terrestrial motion by imparting any fresh motion to the mass? Of course, it would have been impossible for him to comply with such a request, even if it could have been made; but Galileo, having carefully studied the laws of nature bearing upon the subject, discovered certain facts; and by those facts he was enabled, in opposition to the general concensus of opinion, more especially that of the monks, to prove his statements to be correct.

I venture to think that the facts which I have adduced in my letter of the 13th ult. place me in the same position with regard to the proof of the nature of animal life that Galileo held with regard to the motion of the earth; for the nature of the vital force is to be found, and found only (as I believe) in a careful study of general principles, and of the laws of nature.

That I am right in my conclusions will, I think, be ascertained from the following facts:—

1. Animal life holds the same relation to the motion and magnetism of the earth as the earth's motion holds to the motion of the sun, the motion of the planets, and of the celestial bodies in general. That is to say, we cannot conceive of animal life existing except in so far as it is subject to the influences of the earth's motion, magnetism, &c.

2. Every atom of matter, organic or inorganic, has a definite polarity, significant of the mode in which it transmits magnetic force, and of the medium in which it exists.

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3. The capacity of each particle of matter for the magnetic force is fixed, subject to the physical conditions under which the matter exists. This was proved by means of the electro-magnet by Faraday and others.

4. The animal body is composed of particles of matter, which have been combined under the influence of the vital force, subject to the laws which regulate matter in general; and the textures thus formed are permeated in the most complete manner, not only by the vessels and nerves, but by terrestrial magnetism, under the influence of which every particle of matter is at all times polarised.

5. The polarity of the simple inorganic particle is of one description, the polarity of the compound organic particle is of another; and necessarily so, for, in the latter case, the polarity is the sum of all the forces arising from different descriptions of particles which have been combined.

6. No change can be effected in the condition of any description of matter without corresponding changes of magnetic polarity.

7. All vital action consists in a definite series of changes which are constantly being effected in certain conditions of matter, under the directive influence of the magnetic blood current.

8. Every difference in the material condition of the blood corpuscles is bound to be attended with a modified form of molecular motion throughout the animal, according to magnetic laws, which must culminate in the varied phenomena which the different forms of animal life exhibit; and the marvellous significance of those variations in the shape and size of the blood corpuscles which are found in the different forms of animal life is readily perceived.

9. The force impressed upon the particles of matter by the arterial blood corpuscles is not lost, but after exercising an influence, whilst assisting to convey a particle to its destination and developing animal heat, reappears in the formed tissue in the shape of current electricity.

10. Formed and deposited matter is bound to radiate polar influences, *sui generis*, by means of which it is capable of selecting and attracting similar particles to itself, which are then deposited with the same mathematical precision that regulates the process of crystallisation.

11. The proper nerve current is, therefore, the result of reaction induced partly by the flow of the magnetic blood in the adjacent artery—for the arteries and nerves when not in the same sheath run for the most part close to each other—and partly from force impressed at the peripheral extremity of the nerves, from both of which sources the current must be directed towards the nerve centres. It appears, however, that this current is equalised and equilibrium of power established by a counter current in the opposite direction, derived partly from the flow of blood in the veins and partly from other sources, about which it is unnecessary to say more now.

12. When the facts to which I have referred above (and they might be supplemented by a host of others) are fully considered there appears to me to be no room for any other non-physical form of vital force, as is generally believed; for every vital action is capable of explanation by reference to the physical laws of which I have been speaking. In my letter of the 13th ult., I stated that "animal and vegetable life, magnetism and every other form of physical force, are the outcome of one primary motion, viz., the motion of the earth." The question may very properly be asked, In what way does the foregoing testify to the motion of the earth being utilised as a force for maintaining animal life? I venture to think that the solution of the question is not difficult, for we are bound to admit:

1. That every form of terrestrial matter is subject to the earth's motion.

2. That the stress or reaction due to such motion is manifested in a particular direction, which accords with the description of the matter.

3. That the line of least resistance is the axis of force, which determines the situation of the poles.

4. That the magnetic poles of the earth are determined, as I have shown elsewhere, by the mode in which the earth, as a particle of the material universe, deals with the energy of the sun.

5. That every animal body is to be considered as a portion of the mass of the earth, and, consequently, that combination of particles which is found in each portion of the mass, offers, in proportion to its mass, a particular resistance to the motion, by which power is diverted and work is done upon the new system, and such work constitutes the vital phenomena of that particular form of living animal.

6. In vegetable life the matter of which the plant or seed is composed acts as the resisting medium; work is done upon the same principle as in animal life, whilst the radicle is carried into the earth under action, and the plumule ascends under reaction.

7. That all the other forms of physical force are referrible, under the same law, to the same principle; but it is not now necessary to enter into the consideration of those forms of force, the more especially as I have done so in former numbers of *The Electrician*.*

8. I trust the facts which I have brought forward are quite sufficient to prove the *magnetic* state of every *living* animal; and, if so, then there can be no question as to the value of artificial magnets when worn on the surface of the body, more especially when function has been impaired from want of power, also when improper matter, or matter feebly organised (*i.e.*, feebly polarised) enters into the composition of the tissues, for by adding to the sum of the molecular forces the proper organisation and functions of the tissues, as well as the elimination of effete and improper matter, is materially assisted.

9. With such a host of facts before us—facts which are bound to exist so long as matter and the laws of motion to regulate it have any being—I think I am justified in calling upon those who believe in a non-physical vital force to prove that one manifestation of such vital force can take place without being subject to that special form of magnetic force which I have attempted to shadow forth in these letters, and for which I can find no better name than animal magnetism, the more especially as animal life appears to me to be the highest manifestation of magnetic laws.

One word as to the indiscriminate vendors of magnetic appliances. From a scientific standpoint, I take it we have nothing to do with them. There always have existed those who deal in patent medicines, and for my part I cannot recognise that a tithe part of the harm is likely to accrue from magnetic appliances that often arises from patent medicines. It is true also that these appliances may be constructed upon scientific principles or the reverse; they may be applied properly or indiscriminately, and those who are content to apply them upon the latter principle have no right to be disappointed if they do not obtain the desired relief.

I can certainly bear testimony to the beneficial effects of magnetic appliances as adjuncts to other treatment; cases in which the effects of magnetism were most marked.—
Yours, &c., R. C. Shettle, M.D.

PHOTO-ELECTRIC GENERATORS AND SEEING BY ELECTRICITY.

TO THE EDITOR OF THE ELECTRICIAN.

Sir: The storage of electricity, or conversion of energy, is no longer doubted to be the only practical manner of using that abundant source of nature which is evolved in all its actions. The principle of accumulators, or secondary batteries, is now very well known, the conclusion that it is quite practical and fairly economical, the cells being inexpensive in construction and the material cheap. Of course there are many improvements to make before the secondary battery will be perfect and durable. Now, having a fairly practical way by which we can store or accumulate our power, &c., I do not think a few remarks on one or two generators will be premature. Generators, I have long thought, ought to be brought to notice of philosophical and deep thinking minds. We know that the prime mover of life in man or any other living substance is electricity, the different seats of sensations being acted upon by some external cause. For example—the sight, I have no hesitation

* What is Electricity? Vols. 8 and 9.

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in saying, is caused by electricity, the eye being the transmitter or transmitting medium, the brain the receiver of the varying current caused by the variations of the molecules of light, which are projected through the iris, the aqueous chrystalline, vitreous humours, the retina on to the choroids (which is of a very downy and sensitive nature). This being the sensitive seat of sight, conveys the variations through the optic nerve to the brain, which is the receiver, and with which we see. Could we discover a sufficiently sensible transmitter on the above principle, seeing by electricity would no longer be a problem, as we would then convey the variations through one or some of the most suitable nerves direct to the brain. We know that light is, like heat, easily converted into electricity. The photo-electric battery of M. Saur proves to us that it is quite possible to construct a cell which gives a current when exposed to light. The elements of this battery are, I think, sulphide of silver and mercury; the electrolyte is a mixture of marine salt and sulphate of copper; the action is due to the mercury being attacked by the bichloride of copper; the proto-copper formed reduces the silver sulphide; this reduction requires the intervention of light. The current derived from the above arrangement is not very powerful, but I have no doubt, if a few of our minds worked in this direction, we should in the course of a few years be able to arrange a set of photo-electric batteries on the top of our houses, so that the light of the day could be converted into electricity and accumulated in our secondary cells for use at night. We have also the thermo-electric generators, some of which are making great progress. There is, no doubt, a very large field for discovery in this direction; the heat now wasted by every householder would, if properly converted, supply him with more than sufficient light. The action of the atmosphere on some substances and metals only proves to us the abundant supply of electricity there is. In a few generations motive power, &c., on the principle we now obtain it, will not be so cheap; the consumption of fuel s now far in advance of the natural supply. We shall have to look to some other means of obtaining our light, power, &c. Electricity is destined to serve this purpose; it is one of the most abundant sources nature gives. Great names we know have a powerful influence; many a man having made a name, it matters little what he may say, the public will applaud him, but such men as Humbolt, Volta, Cavallo, Crewe, and a few other philosophers of the last century, did much for us. Now we have minds innumerable studying this never failing source of power, with results that will be appreciated by our future generations.—Yours, &c., H. A. KENT.

154, Culford-road, N, Oct. 29, 1883.

MACHINE BANDING.—*ERRATA*.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: The line subsequent to eq. (1) should read "acting at an angle with the horizontal corresponding to the tangent $\frac{L}{D} + \frac{WD}{2TL}$, where T is the tension due to weight of band, being the component of the force p' along the axis of connection."

Again, in eq. (3) the alternative value of s should read, "or $\frac{W}{2V}$."

In the last paragraph on p. 559 "connection" should read "correction," and, further on, "$g = 32{\cdot}2$ of gravitation accellerative" should read "$g = 32{\cdot}2$ or gravitation accelleration."

In the work of flexure equation I intended using λ instead of θ, which was already in use.—Yours., &c.,

T. H. SEYMOUR HAWKER.

ENDLESS CHAIN DYNAMO.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Allow me to remark that the endless chain dynamo designed by Mr. E. L. Voice seems to be an impossibility, even if the chain is composed with alternate iron and non-magnetisable links, because, if a second permanent magnet be put at the place of the solenoid, perpetual motion would be the result.

To explain where resides the error, it suffices to observe that each link in crossing the two magnetic fields is affected in succession by two force integrals equal and opposite in sign.—Yours, &c., DR. G. B. ERMACORA.

Ceresetto, Prov. di Udine (Italy), Oct. 27, 1883.

UTILISATION OF NATURAL FORCES.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Being about to make a series of experiments, extending over twelve months, for determining to what extent the force of the wind can be stored and made available when required for the production of the electric light and transmission of power, I propose to erect a wind engine to drive a dynamo, the current being utilised in the electrolysis of water, the gases being collected under pressure, stored, and afterwards used to drive gas engines, of which three are available, viz., 8 h.-p., 2 h.-p., and ½ h.-p., the 8 h.-p. driving a dynamo to generate a current to drive the cars on the marine electric railway, about one mile in length.

Charging accumulators will also be tried, and their discharge will be utilised in an electric launch, conveying about forty passengers.

Should there be any gentlemen interested in this matter, so that the experiments can be carried out on a larger scale than can be done by myself alone, I shall be glad to hear from them.—Yours, &c., MAGNUS VOLK.

17, Gloster-place, Brighton,
Oct. 31, 1883.

DEFECTIVE FIELD MAGNETS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I am afraid your correspondent "W. M. H." will find on examination that he has wound his field magnets so as to make each leg of similar polarity, thereby neutralising their action, as shown in Fig. 1., instead of winding, as though the wire had to be coiled continuously round the whole length of the magnet.

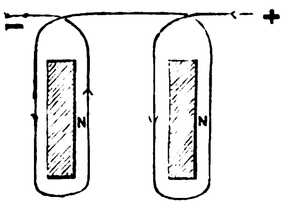

FIG. 1.

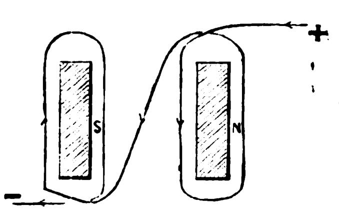

FIG. 2.

In short, after being wrapped round the first leg, it should pass in a diagonal direction towards the second, and then wound upon it, as in Fig. 2.

In each diagram we are supposed to be looking at the ends of the magnet.—Yours, &c., W. H. WHITEHOUSE.

Birmingham.

TO THE EDITOR OF THE ELECTICIAN.

SIR: Referring to your correspondent "W. M. H.'s" difficulty in magnetising the field magnets of his dynamo, I should suggest that they have been connected up so as to form N and S poles in each central bow instead of N N and S S respectively.—Yours, &c., A. B.

PATENTS IN AMERICA.—The electrical patents for 12 months to July, 1882, granted in America, number 1,019, while in the year following, to July, 1883, they amounted to 1,329.

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THE TRANSMISSION OF ENERGY.*

BY PROF. OSBORNE REYNOLDS, M.A., F.R.S.

(CONTINUED FROM PAGE 575.)

Lecture II.—Monday, April 30th, 1883.

In my last lecture I dealt with the transmission of energy through the means of coal and corn, showing that by either of these means power may be transmitted by rail, with an expenditure of 1-12,000th per mile, or by water of 1-120,000th per mile, this either through the agency of horse or steam.

This case of transmission, however, depends entirely on the railroad or water, and is only possible between places so connected. Hence such means are only applicable to what may be called the mains of power.

We come to-day to consider other means of transmitting energy in smaller quantities applicable to its distribution for immediate application. Such transmission is not a matter of secondary importance, although the distances over which it is transmitted may be comparatively insignificant. To emphasise this, I may recall what was previously mentioned—namely, that the relative price of corn and coal shows that the power given out by horses is at least ten times as valuable as that of steam, for more than half the purposes for which energy is used; or that it answers better to burn our coal in bringing corn from America to plough in England, than to use the coal here for ploughing.

In fact, for most of the detailed purposes for which power is used, to draw it from a large source (such as a steam engine), distribute it and adapt it to its purpose, is ten or twenty times more costly than its transportation in large quantities over thousands of miles.

Now, the means of artifically transmitting power may be considered as three. The power may be stored in matter in various ways, and the matter with the energy transported—as, for instance, in our watch springs. The second means is the transmission of power by moving matter, without actually storing the power in the matter—as in shafts and belts, hydraulic connection, &c. And the third method, which is distinct from the others, is the transmission of energy, in the form of heat or electricity, by the flow of currents through conductors. In this way all the power in the steam passes through the boiler plates from the furnace into the boiler. Of course each one of these means includes an infinite variety of detailed contrivances, more or less dissimilar. But there is good reason for classing them under these three heads, for all the contrivances under each of these heads are subject to the same general limits, whether those of efficiency or distance.

There is one thing in common to all these means of transmission, and that is that they all involve a material medium. The quantity of matter required constitutes a primary consideration in all of them. This quantity of matter is fixed by what we may call the properties of matter, one of the most important of which, as regards the first two means, is the possible strength of the material. Looking round, we see the effect of the limited strength of material in all nature's works. Of course it may be that we shall be able to work with stronger materials than we have at present. Organic materials, such as the feathers and tissues of animals, are stronger than steel, weight for weight, so that there is a possibility of improvement, but that man will go beyond nature in constructing organic fibre seems improbable, and such possibility of improvement as exists may be discounted. At present we may set down our strongest working material as steel, the art of working in which is so perfect that we may calculate on nearly the greatest strength for all purposes. I have taken 15 tons on the square inch as the limit of safe working tension in making the estimates which I shall now bring before you. First of all, I will ask your attention to the possibilities of transporting power in a stored form.

The question of economy in the conveyance of energy in a stored form is simply one of the intensity with which it can be stored. If we want to carry energy about, we must have it stored in some material form—and this material has to be carried by ordinary means—so that the question of economy is simply the amount of available energy that we can store in a given amount of material. If energy, stored in a particular manner, is more readily available for some special purpose than that stored in another, then it may, on the whole, be more economical to carry it in that form. This is abundantly illustrated in our watch springs.

The greatest amount of energy that can be stored in a given weight of steel is very small, compared with other means. To take a familiar unit, to store the energy necessary to maintain one horse-power for one hour would require no less than fifty tons of steel—that is to say, fifty tons of steel in the form of watch springs, all fresh wound up, would not supply one horse-power for one hour; and yet this is the commonest form in which energy is carried about.

It is the adaptability of the spring, and the readiness with which energy can be put in and taken out which recommend the steel spring.

India rubber will store much more energy than the same weight of any other material, say eight or ten times as much as steel; but with this several tons would be required to store the horse-power for one hour. A much more capacious reservoir, according to its weight, is compressed air. There are certain difficulties in getting the energy in and out without loss; but with air, compressed to four times the pressure of the atmosphere, we should only require about 20lb. of air to yield the amount of one horse-power for one hour. Of course, if we were going to carry this air about, to the weight of the air would have to be added the weight of a case to contain it, and such a case, in the form of steel tubes, would weigh something like 230lb.; so that, in any form in which we can carry compressed air about, we shall have about 300lb. to carry for each horse-power per hour.

Another means of storing energy, very largely used, is hot water. This is largely used in a way not always recognised. The boiler serves another purpose besides that of converting the energy of the furnace into the power of the steam. It stores the power, and equalises the stream between the fire and the engine, a function the importance of which has been brought to the front in the recent efforts to apply electricity for communication of power, where the want of a similar reservoir between the generator and the motor has, in many cases, proved fatal to the enterprise, a want which secondary batteries are now being used to meet. Hot water has also been employed as an independent reservoir, and as such it is better in some respects than compressed air. The fundamental limits are of much the same kind. In this case, however, the absolute limit is temperature. The vessel in which the water is carried must be strong enough to withstand the pressure, and all materials lose their strength as they get hot. The considerations are here much the same as in the steam engine, and 400° Fahr. appears to be about the limit. At this temperature, for every 4lb. of water the cases would weigh 1lb., and there would be no advantage of large over small cases; except as a matter of construction, the proportionate weight would be the same. The gross power of a pound of water, the steam being used without condensation, is about 20,000 foot-pounds, or we should require 50lb. to store 1,000,000; this is the extreme limit again. The present accomplishment would be about 150lb. per 1,000,000 foot-pounds stored —rather less than compressed air. The only other means of packing power, that is at present looked to, is that of the much-talked-about secondary battery. Here there is a great deal of doubt as to what is actually accomplished; take the most reliable statements, from which it seems that in order to get 1,000,000 something like 100lb. of battery is required, which will make this means of storing energy very much the same as compressed air or hot water.

It is important to notice that the initial cost of the energy stored by these means differs considerably. This cost is rather difficult to estimate; but a practical estimate may be formed in this way:

Taking the power, as delivered by the steam-engine, as 1, how much of this power will be given out after secondary storage? Here the hot water has an advantage, for it is heated directly by the coal, and is all on its way to the steam engine.

With compressed air, there are three operations, each as costly as the steam engine, and at least half the initial power is spent during the compression, storage, and expansion; so that the energy is at least double as costly in coal, and six times as costly in machinery. I have put it down as three times as costly as the energy in hot water, but this is considerably below the mark. The electricity has also to go through three operations, and cannot be less costly than compressed air.

Now, if we revert for one moment to the consideration of the main transmission of power, we see at what an immense disadvantage any form of packed energy is, compared with coal or corn; as at present packed it weighs at least 100 times as much.

While the limits imposed by the strength of material render it certain, as far as compressed air and hot water are concerned, that the weight can never be reduced by more than half, these limits are sufficient to show that packed energy cannot be transported over long distances, even if it can be obtained directly from such falls as Niagara. But this is no argument against the importance of these means for short distances and special purposes. As I have already pointed out, our watches show that circumstances may render the very heaviest means the best for particular purposes. And if in any of its forms packed energy were directly available for household purposes, though it cost ten or twenty times as much as power direct from the steam engine, its use would still be assured.

(TO BE CONTINUED.)

* Cantor Lectures, reprinted from the *Journal of the Society of Arts*.

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EARTH CURRENTS.

Extract from letter from superintendent of Eastern Extension Telegraph Company at Batavia, 9th September, 1883:—

"The distress amongst the population bordering the Java and Sumatra coast, in the Straits of Sunda, is not to be described. There are hundreds now supposed to be dying of starvation, and who cannot be got at by sea on account of the accumulated masses of floating pumice stone. The number of people drowned, starved, and scorched to death will *never* be known, as no registry is kept amongst the natives. In places where entire villages have been washed away the loss of life is estimated by multiplying the sum total of native houses by five, this being the average number of inmates to each house. They will be able to know what number have been buried, as two dollars are being paid to the natives for each body so disposed of; but how many have been driven out to sea and are now being devoured by the sharks in the Straits and by crocodiles along the coast! Of these no vestige will remain. In a sanitary point of view it is, perhaps, good that this is happening, for the stench arising from the bodies that have remained behind, and are being buried, is said to be unbearable.

"The earth currents were so strong during the height of the eruption that we could only work with difficulty, notwithstanding the condensers were in circuit. The movements of the syphon looked for all the world as if some hidden power had appropriated the line for its special purpose. They were not earth currents as we are in the habit of recognising them, but a series of positive and negative impulses resembling the signals from a repairing ship whose electrician has inadvertently used his high testing battery for the one usually employed for signalling. The lightning guards at the Government office sent forth one continual crackling, so strong was the current passing between the line and earth plates. At about noon on the 27th the signals failed entirely, and I left at once for the cable-house, about five miles distant by carriage road, to ascertain the cause. I found on reaching there that a tidal wave had completely wrecked the sea side of the building, leaving a mark behind it on the standing walls, from which I could see that all the testing instruments and lightning guard standing on the table had been over two feet under water. Everything was in the greatest confusion. I hurriedly disconnected the land line and cable from the lightning guard, twisted the two ends together, tied them up as high as I could to a beam, and then ran out of the place as fast as I could, closely followed by a second tidal wave, which, though not high, I was glad to escape.

"It was almost quite dark when I left at noon for the cable house, and the ashes were falling so thickly that people made free use of their umbrellas. The sight was certainly strange. You do not think much in England of a little darkness at noon; but here, ever bright at that hour, the fact of seeing the shops lit up, and carriages with lanterns burning moving about, phantomlike, was really impressive.

"On my return to the office I found that the hurried connection made at the cable house had restored the communication, since which time it has remained undisturbed."

A HISTORY OF ELECTRIC TELEGRAPHY TO THE YEAR 1837.

BY J. J. FAHIE, MEMB. SOC. TEL. ENGS. AND ELECS.*

NOTE.—Being anxious to make his History as complete as possible, the Author will be grateful to his readers for any information, no matter how small, in relation to the subjects treated of in these pages.

CHAPTER IV.—DYNAMIC ELECTRICITY, HISTORY IN RELATION TO TELEGRAPHY.

(CONTINUED FROM PAGE 563).

In the first arrangements made on this principle, the most oxydable metals, such as zinc, tin, and some others, were tried. The oxydating liquid was dilute nitric acid, and the other plain water. In a combination consisting of twenty plates of metal, sensible but weak effects were produced on the organs of sense, and water was decomposed slowly by wires from the extremities. The wire from the end towards which the oxydating surfaces were directed evolved hydrogen, and the other oxygen.

To determine whether the evolution of the electric current was dependent on the production of *oxydation* only, or would attend *other chemical effects* producible by the action of substances in solution upon metal, the oxydating liquid was now replaced by solutions of the sulphurets, and metallic plates were selected on which these solutions would exert a chemical action. Silver, copper, and lead were tried in this way, solution of sulphuret of potash and pure water being the liquids employed. A series of eight metallic plates produced sensible effects. Copper was the most active of the metals tried, and lead the least so. In these cases, the terminal wires produced, in the usual manner, the decomposition of water, the wire from which hydrogen was evolved being that which was connected with the end of the series to which the surfaces of the metal not chemically acted on were presented.

It will be observed that in this case the direction of the electric current relatively to the surfaces of the metallic plates was the reverse of the former. When oxydation was produced, the oxydating sides of the plates looked towards the negative end of the series. Comparing these two effects, Davy was led by analogy to suspect that if one set of cells was filled with an oxydating solution, while the other set was filled with a solution of sulphuret, or any other which would produce a like chemical action, the combined effect of the currents proceeding from the two distinct chemical processes would be obtained. This was accordingly tried, and the results were as foreseen. A series, consisting of three plates of copper, or silver, arranged in this way, produced sensible effects; and twelve or thirteen decomposed water rapidly.

As it appeared from former experiments that charcoal possessed, as a voltaic element, the same properties as the metals, the next step in this course of experiments was, naturally, to try whether a voltaic arrangement could not be constructed without any metallic element, by substituting charcoal for the metallic plates in the series above described. This was accomplished by means of an arrangement in the form of the *couronne des tasses*. Pieces of charcoal, made from very dense wood, were formed into arcs; and the liquids were arranged in alternate glasses. The charcoal arcs were placed so as to have one end immersed in each liquid, the intermediate glasses being connected by slips of bibulous paper. When the liquids were dilute acid and water, a series consisting of twenty pieces of charcoal gave sensible shocks, and decomposed water. This arrangement also acted, and with increased intensity, when the liquids were sulphuric acid and solution of sulphuret of potash.

Soon after the discovery of the pile, Dr. Wollaston also turned his attention to the subject, and in the *Philosophical Transactions*, for 1801 (page 427), records his observations, which are marked by his accustomed sagacity and penetration. He observes that the energy of the pile seems to be in proportion to the tendency which one of the metals has to be acted upon by the interposed fluid. If, he says, a plate of zinc and a plate of silver be immersed in dilute sulphuric acid, and kept asunder, the silver is not affected, but the zinc begins to decompose the water, and to evolve hydrogen. If the plates be now placed in contact, the silver discharges hydrogen, and the zinc continues, as before, to be dissolved. From these and other analogous facts, he concludes, that whenever a metal is dissolved by an acid, electricity is disengaged.*

Davy's experiments have shown that in all voltaic combinations only one of the metallic elements is attacked by the liquid; but this condition, although desirable, is not essential to the production of electricity. It is sufficient if the chemical action of the liquid upon one of the metals be greater than upon the other; for then the two metals may be considered to give rise to two separate currents, of which the one proceeding from the metal most attacked is the stronger, the current perceived being the difference between the two. If the currents were absolutely equal, a condition, however, practically impossible to realise, we must assume that no electrical effects would be produced.

As a voltaic current, then, is produced whenever two metals are placed in metallic contact in a liquid which acts more powerfully upon one than upon the other, it is easy to see that there must be a great choice in the mode of producing such currents. The following is a list of the principal metals, arranged in what is called an *electromotive series*, and from which any two being taken and placed in contact in, say, dilute sulphuric acid, that metal highest in the list is the one that will suffer oxydation.

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* The author reserves all rights of translation.

* He extends this principle to the action of the electrical machine, which, he conceives, has its power increased by applying an amalgam to the cushion, into the composition of which enters an easily oxydable metal. As a further illustration of the same principle, he found that the machine will not act when immersed in carbonic acid gas.

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This is called the *electropositive* metal in contradistinction to its fellow, which is denominated *electronegative* :—

Zinc.	Antimony.
Cadmium.	Copper.
Tin.	Mercury.
Lead.	Silver.
Iron.	Gold.
Nickel.	Platinum.
Bismuth.	Graphite.

It will be seen that the electrical deportment of any metal depends upon the metal with which it is associated. Iron, for instance, is electronegative towards zinc, but electropositive towards copper; while copper, in its turn, is electronegative towards iron and zinc, but electropositive towards silver, platinum, or graphite.

The force resulting from the contact of two metals in a liquid is called the *electromotive force*, and, as may be supposed, is greater in proportion to the distance of the two metals from one another in the above list. Thus, the electromotive force between zinc and platinum is greater than that between zinc and iron, or between zinc and copper. Indeed the law, as established by Poggendorff, is, that the electromotive force between any two metals is equal to the sum of the electromotive forces between all the intervening metals. (Ganot's "Elementary Treatise on Physics," London, 1863, p. 604.)

The electromotive force is influenced by the condition of the metal; rolled zinc, for example, is negative towards cast zinc. It also depends on the *degree of concentration* of the liquid; thus, in dilute nitric acid zinc is positive towards tin, and mercury positive towards lead; while in concentrated nitric acid the reverse is the case, mercury and zinc being respectively electronegative towards lead and tin.

The *nature* of the liquid is also of influence, as is seen from the change in the relative position of the metals in the following lists :—

Caustic Potass.	Sulphide of Potassium.
Zinc.	Zinc.
Tin.	Copper.
Cadmium.	Cadmium.
Antimony.	Tin.
Lead.	Silver.
Bismuth.	Antimony.
Iron.	Lead.
Copper.	Bismuth.
Nickel.	Nickel.
Silver.	Iron.

In short, anything that affects the energy of the chemical action on the positive plate, or the resultant actions on the two plates, affects to a like degree the electromotive force of the combination.

Of the theories proposed to explain chemical decomposition by the voltaic apparatus, that of Grotthus was the earliest and most plausible. To simplify the view of this theory, we shall take as an example of its application the decomposition of water. Each molecule of water being composed of a molecule of oxygen and a molecule of hydrogen, their natural electricities are in equilibrium when not exposed to any disturbing force, each possessing equal quantities of the positive and negative fluids. The electricity of the positive wire acting on the natural electricities of the contiguous molecule of water, attracts the negative and repels the positive fluid. It is further assumed in this theory, that oxygen has a natural attraction for negative, and hydrogen for positive electricity; therefore the positive wire in attracting the negative fluid of the contiguous molecule of water, and repelling its positive fluid, attracts its constituent molecule of oxygen, and repels its molecule of hydrogen. The particle of water, therefore, places itself with its oxygen next the positive wire, and its hydrogen on the opposite side.

The positive electricity of the first particle of water thus accumulated on its hydrogen molecule, produces the same action on the succeeding molecule of water as the wire did upon the first molecule; and a similar arrangement of the second molecule of water is effected. This second molecule acts in like manner on the third, and so on. All the particles of water between the positive and negative wires thus assume a polar arrangement, and have their natural electricities decomposed; the negative poles and oxygen molecules looking towards the positive wire, and the positive poles and hydrogen molecules looking towards the negative wire. The attraction of the positive wire now separates the oxygen molecule of the contiguous particle of water from its hydrogen molecule, neutralises its negative electricity, and either dismisses it in the gaseous form, or combines with it, according to the degree of the affinity of the metal of the wire for oxygen. The hydrogen molecule thus liberated effects in like manner the decomposition of the second particle of water, combining with its oxygen, and thus again forming water and dismissing its hydrogen. The latter acts in the same manner on the next particle of water, and so on.

Thus, a series of decompositions and recompositions are supposed to be carried on through the fluid, until the process reaches the particle of water contiguous to the negative wire, and the molecule of hydrogen there disengaged gives up its positive electricity, by which an equal portion of negative electricity proceeding from the wire is neutralised, and the molecule of hydrogen escapes in the gaseous form. It is equally compatible with this theory to suppose the series of decompositions and recompositions to commence at the negative and terminate at the positive wire, or to commence simultaneously at both, and terminate at any intermediate point by the union of the last molecule of oxygen disengaged in the one series with the last molecule of hydrogen disengaged in the other.

Grotthus illustrated this ingenious hypothesis by comparing the supposed phenomena with the mechanical effects produced when a number of elastic balls—ivory balls for example—being suspended, so that their centres shall be in the same straight line, and their surfaces mutually touch, either of the extreme balls of the series being raised and let fall against the adjacent one, the effect is propagated through the series, and the last ball alone recoils in consequence of the impact; and although the action and reaction are suffered by each ball of the series, and each is instrumental in transmitting the effect, no visible change takes place in any ball except the last.*

The investigations of which the pile became the instrument now began to assume an importance which rendered it necessary to give it greater power, either by increasing its height, or by enlarging the surfaces of the plates. In either case, inconveniences were encountered which imposed a practical limit to the increase of its power. When the number, or magnitude, of the discs was considerable, the incumbent pressure discharged the liquid from the intermediate card-board, so that the energy of the pile gradually diminished from the first, and ultimately ceased altogether. It had then to be taken to pieces, the metals cleaned, and the card-board re-soaked in the solution, every time it was required.

Volta himself, seeing these inconveniences, proposed an arrangement which he called *la couronne des tasses*, and which consisted of a circle, or row, of small cups containing a solution of salt. In each cup were placed a small plate, or bar, of zinc, and another of silver, not touching, the zinc of the first cup being connected metallically to the silver of the second, the zinc of this to the silver of the third, and so on. The silver rod of the first cup and the zinc rod of the last formed the poles of the apparatus. Twenty such combinations were able to decompose water, and thirty gave a distinct shock to the moistened hands.

A still more convenient form was that known as *Cruickshank's Battery*, which was introduced in 1800, within a few weeks of the announcement of Volta's discovery. It consisted of a number of pairs of zinc and copper plates soldered together and cemented into grooves in an oblong trough of wood, the spaces between each being filled with the exciting liquid. On this plan was constructed the great battery of 600 pairs given to the Polytechnic School of Paris by Napoleon I., and with which Gay Lussac and Thénard made their experiments in 1808.†

Dr. Babington's arrangement was a great improvement upon this form. The plates of copper and zinc, four inches square, were united in pairs by soldering at one point only. The trough in which they were immersed was made of porcelain, and divided into ten, or twelve, equal compartments. The plates were attached to a strip of wood, well baked and varnished, and so arranged that each pair should enclose a partition between them when let down into the trough. By this means the whole set could be lifted at once into, or out of, the little cells, and thus, while the exciting fluid remained in the trough, the action of the battery could be suspended at pleasure, and the plates, when corroded, could be easily replaced.

A battery of 2,000 pairs, with a surface of 128,000 square inches, was made on this plan for the Royal Institution of London, with which Davy and Faraday performed those long-continued and brilliant series of experiments, for which the

* Lardner's "Electricity, Magnetism, and Meteorology," Vol. I., pp. 135-37.

† An amusing story *anent* this battery is told in Dr. Paris's "Life of Sir Humphry Davy" :—When Napoleon heard of the decomposition of the alkalies by an English philosopher, he angrily questioned the *savans* of the Paris Institute why the discovery had not been made in France. The excuse alleged was the want of a battery of sufficient power. He immediately commanded one to be made, and when completed he went to see it. With his usual impetuosity, the Emperor seized the terminal wires, and, before he could be checked by the attendant, applied them to his tongue. His Imperial Majesty was rendered nearly senseless by the shock, and as soon as he recovered from its effects he walked out of the laboratory with as much composure as he could assume, not requiring further experiments to test the power of the battery, nor did he ever afterwards allude to the subject.—(Vol. II., page 24.)

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Royal Institution will ever be celebrated.* Children in 1809, Wollaston in 1815, Berzelius in 1818, and others proposed various modifications of the trough battery, all having for their object increase of power, with more cleanliness and less waste.

But all these arrangements of two metals in one fluid, constituting what are now called *single-fluid batteries*, had one great defect: their power, variable from the first, rapidly declined, and, sooner or later, ceased altogether.

This defect was due to two causes, first, the decrease in the chemical action owing to the neutralisation of the sulphuric acid by its combination with the zinc; second, *polarisation* of the negative, or copper, plate, giving rise to *secondary currents*. These are currents which are produced in the battery in a contrary direction to the principal one, and which destroy it, either totally, or partially. In a couple of zinc, copper, and sulphuric acid diluted with water, for example, when the circuit is closed sulphate of zinc is formed which dissolves in the liquid, and at the same time a layer of hydrogen gas, in what is called its *nascent* state, is gradually deposited on the copper.

Now, it has been found that hydrogen deposited in this manner on metallic surfaces acts far more energetically than ordinary hydrogen. In virtue, therefore, of this increased action it gradually reduces some of the sulphate of zinc dispersed in the liquid, causing a layer of metallic zinc to be formed on the surface of the copper plate; hence, instead of having two different metals, copper and zinc, we have two metals becoming gradually less different, and, consequently, in the connecting wire there are two currents in opposite directions tending to become equal, and so to neutralise one another. When the copper plate is entirely covered with zinc the action of the couple ceases, for the condition essential to this action no longer exists, viz., two dissimilar metals.

Becquerel, of Brussels, was the first to recognise these causes of the inconstancy of the voltaic battery, and, in 1829, he devised the first double-fluid arrangement, which, while it prevented polarisation, maintained the supply of acid around the positive plate, thus removing both sources of weakness at once.

It was composed of two small glass vessels, one of which contained concentrated nitric acid, and the other a solution of caustic potash, also concentrated. The two vessels communicated with each other by means of a bent glass tube, filled with fine clay, moistened with a solution of sea-salt. In the vessel which contained the alkali was immersed a plate of gold, and in the other a plate of platinum. By connecting the two through a galvanometer a tolerably energetic current was perceived, resulting from the reaction of the acid on the sea-salt and potash. (*Comptes Rendus*, for 1837, No. 2.)

In 1830 Wach constructed double-fluid batteries on this plan, using animal bladders as the separating membrane.

Professor Daniell, of King's College, London, is commonly supposed, in England at all events, to have been the first to make a double-fluid battery; but although he was not the first, as we see, his independent researches and his beautiful memoir on the subject, in the *Philosophical Transactions*, for 1836, were the means of bringing the improvement into general notice, and hence, no doubt, the popular belief.†

Double-fluid batteries are so simply constructed nowadays that our readers will probably be surprised to learn the pains that Daniell was at in contriving his. Fig. 2 represents a section of one of his original cells; *a, b, c, d*, is a cylinder of copper, six inches high and three and a-half inches wide; it is open at the top *a, b*, but closed at the bottom, except for a collar *e, f*, one inch and a-half wide, intended for the reception of a cork into which a glass syphon tube *g, h, i, j, k* is fitted water-tight. On the top *a, b*, a copper collar, corresponding with the one at the bottom, rests by two horizontal arms. Previously to fixing the cork, a membranous tube, formed of part of the gullet of an ox, is drawn through the lower collar *e, f*, and fastened with twine to the upper, *l, m, n, o*, and, when tightly fixed by the cork plug below, forms an internal cavity to the cell, communicating with the syphon tube, so that, when filled with any liquid to the level *m, o*, any addition causes it to flow out at the aperture *k*.

* "When the whole series was put into action, platina, quartz, sapphire, magnesia, and lime, were all rapidly fused; while diamond, charcoal, and plumbago, in small portions disappeared, and seemed to be completely evaporated. A singularly beautiful effect was produced by placing pieces of charcoal at the two ends of the wires; when they were brought within the thirtieth, or fortieth, part of an inch of each other, a bright spark was produced, above half the volume of the charcoal, which was rather more than an inch long, and the points became ignited to whiteness. By withdrawing them from each other, a constant discharge took place through the heated air, in a space equal to at least four inches, producing a most brilliant arc of light" (Bostock's "History of Galvanism," p. 95).

† For much valuable information on this question, as between Daniell and Becquerel, see Sturgeon's *Annals of Electricity*, Vol. IX., pp. 534—549. Zetzsche, at page 45 of his "Geschichte der Elektrischen Telegraphie," says that Dobereiner, Privy Councillor at Jena, had, as far back as 1821, constructed such a battery as the constant form of Daniell.

The objects which Daniell proposed to himself in constructing this cell were (1) the removal of the oxide of zinc as fast as formed, and (2) the absorption of the hydrogen evolved upon the copper, without the precipitation thereon of any substance that could impair its action.

The first he effected by suspending the zinc rod, which he took care to be amalgamated,* in the interior membranous cell, into which fresh acidulated water was allowed slowly to drop, from a funnel suspended over it, whose aperture was adjusted to this purpose; whilst the heavier solution of the oxide was withdrawn from the bottom at an equal rate by the syphon tube. The second object was attained by charging the exterior space surrounding the membrane, with a saturated solution of sulphate of copper. When the circuit was completed the current passed freely, no hydrogen was observed to collect on the negative plate, but, instead, a beautiful pink coating of pure copper was deposited upon it, and thus perpetually renewed its surface.

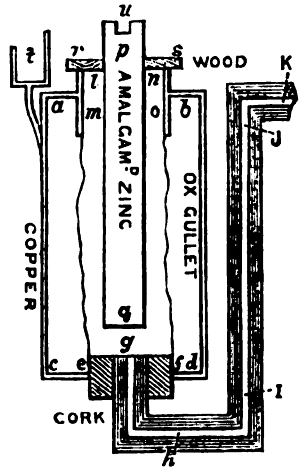

Fig. 2.

Although this cell was much more steady and permanent in its action than one of the ordinary single-fluid construction, it still showed a gradual but very slow decline, which Daniell traced to the weakening of the saline solution by the precipitation of its copper and consequent decline of its conducting power. To obviate this defect some crystals of sulphate of copper were suspended in muslin bags, which just dipped below the surface of the solution in the copper cylinder, and which, gradually dissolving as the precipitation proceeded, kept the solution in a state of saturation. This expedient fairly answered the purpose, and its author was delighted to find that "the current was now perfectly steady for six hours together."

Such, in brief, is the evolution of the far-famed Daniell cell. Its further development we need not pursue in these pages, as all the later forms, as well as many other kinds of double-fluid, or so-called *constant*, batteries, are to be found in all the text-books on electricity.

Postscript.

Since the first sheets of this chapter were published we have discovered in the *Philosophical Transactions* (for 1732, Vol. 37, p. 327), some experiments of so appropriate a character as to deserve reproduction here. It will be seen that they are of exactly the same nature as those of Swammerdam in 1678, and du Verney in 1700, immediately after which they should be read. The paper from which we quote is headed "Experiments to prove the existence of a fluid in the nerves," by Alexander Stuart, M.D.:—

"The existence of a fluid in the nerves (commonly called the *animal spirits*) has been doubted of by many; and, notwithstanding experiments made by ligatures upon the nerves, &c., continues to be controverted by some. This induced me to make the following experiments, which I hope may help to set that doctrine, which is of so much consequence in the animal economy and practice of physic, in a clearer light than I think it has hitherto appeared in:—

"Experiment I.

"I suspended a frog by the fore legs in a frame leaving the inferior parts loose; then, the head being cut off with a pair of scissors, I made a slight push perpendicularly downwards, upon

* The first mention of amalgamated zinc in voltaic arrangements occurs in Sir H. Davy's Bakerian lecture, for 1826, in which he simply remarked that "zinc in amalgamation with mercury is positive with respect to pure zinc" (*Phil. Trans.*, 1826, part III.), without any allusion to the probable beneficial employment of it in the general construction of batteries. Kemp of Edinburgh was the first to employ amalgamated zinc and copper in the regular construction of batteries. (See his paper in Jameson's *New Edinburgh Philosophical Journal*, for Dec., 1828.)

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the uppermost extremity of the *medulla spinalis*, in the upper vertebra, with the button-end of the probe, filed flat and smooth for that purpose; by which all the inferior parts were instantaneously brought into the fullest and strongest contraction; and this I repeated several times, on the same frog, with equal success; intermitting a few seconds of time between the pushes, which, if repeated too quick, made the contractions much slighter.

"Experiment II.

"With the same flat button-end of the probe, I pushed slightly towards the brain in the head, upon that end of the *medulla oblongata* appearing in the occipital hole of the skull; upon which the eyes were convulsed. This also I repeated several times, on the same head with the same effect.

"These two experiments show that the brain and nerves contribute to muscular motion, and that to a very high degree."

In their results these experiments were precisely the same as those with which the name of Galvani is associated. Nor was the mode of operating very different, even in the use of only one kind of metal. In Galvani's experiments, excitation was produced by contact, or communication, of nerves and muscles. In Stuart's the convulsions were produced by exciting the spinal marrow.

(TO BE CONTINUED.)

THE BRAZILIAN SUBMARINE TELEGRAPH COMPANY (LIMITED.)

The twentieth ordinary general meeting of the shareholders of this Company was held at the City Terminus Hotel on October 26, 1883, under the presidency of the Right Hon. Viscount Monck.

The SECRETARY (Mr. Richard Collett) read the notice calling the meeting, and afterwards read the minutes of the last meeting, which were confirmed by the present meeting and signed as correct by the chairman.

The report of the directors was taken as read.

The CHAIRMAN, in moving the adoption of the report and accounts, and the payment of a dividend of 3s. a share, making, with the interim dividends, a dividend of 6 per cent., free of income tax, for the year ended June, 1883, said that if he had only to deal with the report proper of the half year ending June 30 last his task would be very light, inasmuch as he would have to report the same continuance of prosperity which it had been his privilege to refer to during the last ten years. There was really nothing in the half-yearly accounts to distinguish them from those which had preceded them, and the directors were fully prepared and intended at the end of the half year to have given the usual dividend and bonus of 1 per cent. There was only one observation which he would have had to make if they had held their meeting on the 1st July, and that was that their electricians had reported to them that the section of cable from Madeira to St. Vincent had developed a certain diminution of insulation. He believed that experts would tell them that, though that was of course more or less against the cable, it was quite consistent with its continuing to work for a very long time. That state of things continued until the 22nd September, when, without any warning whatever, they received intelligence that the section of cable between St. Vincent and Pernambuco had ceased working. Until the cable was raised it was impossible to say what had caused the suspension of working, but as a matter of speculation he could not refrain from thinking that there was some connection between it and the great volcanic disturbances which had occurred all over the world, and for which this year had become so notable. When this intelligence arrived the directors were away on their holidays, but fortunately the managing director was in London, and he communicated with him (the chairman) by telegraph, and within twenty-four hours steps were taken for fitting out a repairing expedition. His lordship then referred to an anonymous circular which had been issued *àpropos* of the breakage of the section referred to, and stated in answer to certain criticisms of the writer that the Company did possess a limited amount of cable ready made. On previous occasions, however, he (the chairman) had been taken to task for keeping cable in stock, as that rendered unproductive a certain amount of the Company's capital. In many cable companies there were repairing ships. That was the case with the Anglo-American Company, of which he was chairman. That company constantly kept a repairing ship at Newfoundland, but that was because there were a large number of cables in shallow water on the other side of the Atlantic, and those cables were liable to accidents which did not occur in deep water, and a comparatively inexpensive ship was kept to undertake the repairs. But the breakage of the section of this Company's cable to which he had referred was in about 2,000 fathoms of water, as far as they could make out, and to lift and repair a cable at that depth would require a large ship thoroughly fitted up for the purpose, and it would never pay the Company to maintain such a vessel perpetually. They might rely upon it that the only real preparation for a disaster of that kind was to have the money in hand ready to accomplish the object, and that fortunately was the position of this Company. The repairing expedition would sail at the end of this month. The fact was that the Telegraph Construction Company had been obliged to manufacture cable for the purpose. The experts were sanguine that they would be able to make an effectual repair of the cable, and to restore it to its former condition, but he thought the best plan was to contemplate the worst that could happen, and not to speculate on everything turning out favourably; and assuming for a moment that the repair could not be effectually accomplished, the loss of revenue produced by a complete suspension of the Company's traffic for a so much longer period would be a risk which the directors thought they ought not to incur. They had, therefore, determined to duplicate the whole system, and they had received a tender for the work which would enable them to carry it out, with the assistance of their reserve fund, without raising a shilling of additional capital. The electricians had assured them that they would then have the cheapest deep sea cable that had ever been laid. Of course it was disagreeable to meet the shareholders with a statement in which he had to refer to the occurrence of such a misfortune, but on the other hand he might inform them that the Lisbon-Madeira section which was duplicated was in as good a position as it could possibly be in. As to the breakage to which he had referred, he thought the wisdom of the policy which had been adopted of accumulating a substantial reserve fund was now proved. He then referred to the high price which the shares had kept at, in spite of the circumstances to which he had alluded, and said that he thought that this fact showed the confidence of the public in the Company's stability, and also the confidence of the shareholders in the mode in which their affairs had hitherto been conducted. He had little doubt—in fact if it were not presumptuous he would say it was certain—that within a very few weeks they would revive their cables and recommence the receipt of their income without at all interfering with the payment of the dividend which the shareholders had been accustomed to receive. He concluded by moving the resolution.

Sir THOMAS FAIRBAIRN having seconded the motion,

Mr. SPICER considered that the present was the most important meeting of the Company that had ever been held in view of the decision of the directors to duplicate the cable. He thought the decision the shareholders came to would determine the value of their property for all future time. He then referred to the active part which he took at two former meetings of the Company, especially alluding to his opposition to the policy of the directors in regard to building up a large reserve fund, contending, as he had done, that that policy needlessly restricted the amount of dividend paid. On the last of the two occasions to which he referred, when the reserve fund amounted to over a quarter of a million, and they were paying only 6 per cent. dividend, he moved a resolution to the effect that the reserve fund should be restricted to a small amount, in order that the shareholders might get a larger dividend. The Chairman, however, declined to put the resolution, a course which he (Mr. Spicer) maintained was unjustifiable. At some length he proceeded to contend that the policy of building up the reserve fund had been opposed to the interests of the shareholders, and that it was not to their interests that the cables should be duplicated, a proceeding which he argued was not absolutely necessary. If their system were duplicated there would be six cables instead of three, and he maintained that it was probable that the repairing expenses would, therefore, be much larger. The reserve fund, too, would be swept away, and it would have to be built up again. But for the monopoly which the company had enjoyed they would, he said, assuredly have had a competing cable, and they must look for that contingency at the expiration of their concession ten years hence. If the cable were duplicated the capital would be enormously increased, and the shareholders would be receiving when their concession ceased an insignificant amount of dividend compared with the shareholders in the competing Company, owing to the much smaller capital of the latter. He pointed out the large amount of the earnings which were distributed by the Submarine Telegraph Company, and the small amount, comparatively, which that Company added to their reserve fund. Nevertheless, that Company was admirably managed, and their shares were at 120 premium, as compared with the shares in this Company, which were just a little over par. In conclusion, he moved an amendment appointing a committee of inquiry into the matter, with authority to report their opinion to the shareholders.

Mr. BRICE seconded the motion.

The CHAIRMAN said he must decline, but out of no disrespect to Mr. Spicer, to follow that gentleman through the long statement which he had made. He would, therefore, at once put the amendment, which meant neither more nor less than this—that those who voted for it entertained no confidence in the mode in which the Company had hitherto been managed. He was certain, however, that the amendment would be negatived by a very large majority. Having put it in the usual way, he said that there was no doubt as to the manner in which it had been received (it having been rejected by an overwhelming majority; only two hands were held up in favour of the amendment).

Mr. GRIFFITH thought that the able address of the chairman must have carried conviction to the minds of all present. He thought the time had arrived when the cables were wearing out, and he acquiesced in the advisability of their being duplicated. As to competition that was a contingency in the future, and ought not to prevent them from providing against a danger which was actually present, and he thought they would be in a better position with their system duplicated to go to the Brazilian Government and ask them for a renewal of the concession. The Submarine Company might be able to lay aside a small reserve fund every year because their cable was so small, whereas the cable of this Company was very large. He thought it was rather surprising that the Telegraph Construction and Maintenance Company, which gained so much profit from the repairs of cables, had not stock in hand by which this Company's cable might have been repaired more quickly. He urged the shareholders to support the directors.

In reply to Mr. Matthey,

The CHAIRMAN repeated that the duplication of the cable would not increase the share capital of the Company, but, of course, £400,000 would not duplicate between 3,000 and 4,000 miles of cable. The outside limit of money which it would be necessary to raise to duplicate the cable would be about £250,000, and this amount, or the amount which might be required, would be raised by debentures, and offered in the first instance to the shareholders, and any portion which they did not take had been already provided for.

Mr. BRICE asked if the duplication of the cable would bring them more business.

The CHAIRMAN said that he did not think it would, but it would enable them to do their business more thoroughly. As an allusion had been made to competition, he might say that he had no reason to believe that there was any intention on the part of the Brazilian Government to interfere directly with the concession held by the Company. However, there existed a cable which indirectly competed with them, but that competition had been going on for more than a year, and they had no reason to believe that it had interfered with the Company's traffic.

Mr. NEWTON desired to point out, as the question of competition had been raised, that messages sent by the competing cable had to be sent

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through England to North America (at the outset that did not seem like competition), then down by land lines to the Gulf of Mexico, across the Gulf of Mexico to Panama, thence to the west coast of South America, across the Andes to Buenos Ayres, and thence by the Monte Video cable, and so on to Brazil. Such competition as that he thought could scarcely be considered real competition.

The CHAIRMAN was much obliged to Mr. Newton for the observations which he had made. Mr. Newton's geographical knowledge had completely enlightened the meeting as to the competing system.

Mr. F. H. NEWMAN referred to the observations which he had made at a former meeting as to the advisability of duplicating the Company's system, and expressed his gratification that the Board had come to the decision to carry the work out.

The CHAIRMAN then put the original resolution, and declared it carried unanimously.

The retiring directors, Sir James Anderson and the Hon. William St. John Brodrick, M.P., were re-elected, as were also the retiring auditors, Mr. Henry Dever and Mr. John Gane.

On the motion of Mr. John Newton, seconded by Mr. Matthey, a hearty vote of thanks was passed to the chairman and directors.

THE WEST INDIA AND PANAMA TELEGRAPH COMPANY (LIMITED).

The thirteenth ordinary general meeting of this Company was held on Wednesday at the Cannon-street Hotel, Mr. C. W. Earle in the chair.

Mr. R. T. BROWN (the secretary) read the notice convening the meeting, and the report of the directors was taken as read.

The CHAIRMAN said: The report deals with a half year which has been, perhaps, the least eventful of any that we have had since we have been in office. We have only had an interruption of communication with one station in the whole of our twenty-three. There have been some other repairs on the duplicate lines, but only one station cut off from communication. We took advantage of the immunity from interruptions to continue our investigations of the very important cable which you will see marked there red, between Jamaica and Porto Rico, with the black patch on it. That cable has been unproductive ever since this Board took office. We have never had time to do more than occasionally investigate certain portions of it; but, as I said before, during the last half year, our ships not being so fully employed as they generally have been, unfortunately, we were able to prosecute the inspection of that line, that very important line, and we found that there was a very considerable amount of the old cable in very good condition. We therefore resolved to bring home our ship, the "Grappler," which had been a considerable time in the West Indies, and wanted to be overhauled, which could be more effectively and thoroughly done in London than in the West Indies, and could at the same time take out a supply of cable and further replenish the stock. We therefore called for tenders, as usual in this Company, and we obtained 250 miles at the most reasonable—in fact, at the lowest rate we have known at all, I think, in our experience. With the cargo of cable the "Grappler" sailed. She arrived at St. Thomas on the 20th of the month. She had a very good passage, and on the day before yesterday, having discharged the cable, she left to pick up the end near Porto Rico, and intended to lay on towards the black patch. I hope she will be able to take out the other faults and put the cable into working order. Of course it is a speculation dealing with a cable in such depths of water as we have to work in—not that they are anything very excessive, but still they are very considerable depths—and this repair may run into a great deal of money; in fact, if we find that we cannot complete the repair the amount of capital that that cable represents will have to be written off before we can pay any dividends at all. Turning now to the accounts, it is satisfactory to find that on the revenue side we have the largest receipt of revenue that we have ever had. It is £6,000 more than it was in the corresponding period of last year, and that again was in excess of anything we had previously had. This £6,000, it must be remembered, is partly made up of the results of an accident to another line. There is about £2,000 which came to us in traffic caused by the interruption of a competing line that had been laid down to Panama along the west coast of the Isthmus; therefore, so far, that is an accidental element in the increase. The increase in the subsidies, £2,400, is thoroughly satisfactory in every way. It indicates that our colonies are beginning to have more confidence in us, and to appreciate what we are doing in the way of securing the communications which are of such vital importance to them, and it is altogether a most satisfactory indication of the better feeling that is growing up. It is this better feeling, no doubt, which has caused the colony of Trinidad to more than double its subsidy, as you will observe, and British Guiana to increase theirs, as mentioned in our last report. I think these results are the rewards of the prudence and the self-denial, I may call it, of the shareholders of this Company in forming a reserve fund. The remaining colonies, the Antilles (these are the Windward Islands and the Leeward Islands), have not yet assented to give us an increase, but I am in hopes, from what I hear, that certainly the Leeward Islands will very soon follow the example of Trinidad. I had the pleasure of meeting the Governor, Sir John Glover, here the other day. I spoke to him on the subject, and he assured me of the good feeling that existed towards us in the colonies; and I think when they meet in session, as they do at this time of the year, we may expect an increased grant, which has already been voted, but not carried into effect pending the action of other colonies. Well, I think the general aspect of our position is improving very much. This is, no doubt, a good deal attributable, as I said before, to our prudence in setting aside this strong reserve. We have always heard stated in the colony, and it has been one of the strongest arguments against giving us any increase, that we were an impecunious Company, unable to carry out what we had undertaken to do, and that it was perfectly useless increasing subsidies; it was only throwing money into the sea or putting it into the pockets of the shareholders, and it would not help to keep up the system on which they depended. We have, however, rectified that, and are growing towards a very important reserve fund, and the policy has certainly had its good fruits, and in proof of it I should like to read you what the Governor of Trinidad writes to me under date of the 24th of July. In communicating the increase that his colony has granted he says:—"I have however, reconsidered my decision in view of the great effort which the Company has lately been making, and is continuing to make, to improve its cable communication, which has proved beneficial to these colonies; and I have, therefore, sanctioned the increased subsidy from the commencement of the present year, which the Crown Agents will be instructed to pay."

Mr. HORA: Will that be permanent?

The CHAIRMAN: Well, as long as we are in operation.

Mr. HORA: There is no limitation?

The CHAIRMAN: There is no limitation.

Mr. HORA: The one last year was for three years.

The CHAIRMAN: For ten years. Well, gentlemen, we have all of us received a circular this morning or last night. That circular indicates a policy which I think it would be most dangerous, at the present juncture, to give effect to. It advocates a large increase to our capital account. Now, pending the negotiations we are still carrying on with the colonies, and pending the results of our attempt to repair the Porto Rico-Jamaica cable, I do think that anything like an increase of capital account at this moment would be very fatal. Not only did the colonies object to give us anything so long as we had no reserve fund, but they always said, "Your capital is very much too large"; and what now would be the effect at this juncture if we were to take a step which would really very much tend, I think, to dry up the liberal intentions which seem indicated at this moment by adding a very large sum to our capital account. I think that nothing could be more suicidal than to press forward such a measure as that. I am very sorry the circular has been issued, because it indicates to the colonies what is proposed to be done directly we get all we can out of them. Having had the management, as we have had, of these long negotiations with the colonies, I think it has been a most injudicious move to put this before the public in any shape whatever. The gentleman who does so is not a shareholder in this Company, and I really do not know what philanthropic incentives and motives he has in taking such interest in our concern. I think he has certainly taken a step which is not conducive to the welfare of the Company at present. As time goes on no doubt we shall have to consider what is to be done. I think there are indications of our being in a better position if you will only let well alone, and let us carry out what we are doing at this moment; therefore I hope, gentlemen, that whatever discussion takes place it will not be of such a nature as will prejudice us in our relations with these colonies. The whole management of this affair is most difficult and intricate, and if we have an expression of opinion here on the part of the shareholders showing they wish to reverse the policy of the directors in regard to the reserve and keeping the capital as low as possible, I cannot answer for the result as to what will be the decision of the colonies who have not given us any increase yet. I shall be happy to answer any questions that may be put to me, and will move the resolution, "That the directors' report and accounts to 30th June, 1883, be, and the same are hereby received and adopted, and that, as recommended by the Board, a payment of 3s. per share on account of arrears of dividend on the first Preference shares be and the same is hereby declared.

Mr. W. FORD: I beg to second that.

Mr. MORTEN: Mr. Chairman and gentlemen—I am sure you will acquit me of any personal feeling in the remarks I am about to make, but I have carefully studied the accounts for the past three years, and I am very happy to say that the position of affairs is not nearly so gloomy as one would imagine. I have carefully gone into the two balance-sheets of last year, and I find at the present time we are actually earning a dividend on the ordinary shares. Now, I do not wish to tie the hands of the directors in any way, but, considering that the market value of our property is probably lower than it ever was before, with the exception of about a fortnight ago, it is only justifiable to ourselves to see what we can do to place our affairs on a better footing. Now, gentlemen, we have a very large reserve fund indeed—£81,000.

The CHAIRMAN: No, sir, it is not a large reserve fund. Do you know how many miles of cable we have got submerged?

Mr. MORTEN: Yes, sir, and I know we have £81,000, besides about £9,000 towards the depreciation of ships. Now, the whole of the arrears on the first and second Preference would only amount to about £60,000; we could very easily, I say, pay off about half of that £30,000 now and another £30,000 in six months. We should still have a good reserve fund, and the value of the property would be so tremendously increased by what I call a fair policy on the part of the Board, that if we wanted a reserve fund we should be able to negotiate some of the securities. I do not approve of this circular; I say so candidly. I would not increase the capital at the present moment, but when we have £80,000 or £90,000 only giving 2 per cent. lent on securities, we are doing very wrong in our own interests. The whole of the income, taking the past half year and the half year under consideration, was nearly £93,000. Since then we know we have an increase this half year, so that taking this whole year we may roughly anticipate we shall have at least a gross income of £100,000. The entire expenses for the two previous half years were £57,000; this will leave a surplus, roughly speaking, of £43,000. The arrears on the first and second Preference weigh on the property frightfully. No one can be induced to come into it, and if they were only wiped away, and if we would only act in a commercial spirit, and lift off the incubus, we should still have a very fair reserve fund, and we could then pay the Preference dividends in full as they went along, discharge our liabilities to the shareholders, because they are liabilities to the shareholders, and we should be in a good commercial condition. We should be actually earning a dividend on the Ordinary shares. Now with that £100,000, if the arrears of dividend were cleared away, and the working expenses taken into account, there would be a dividend of 4s. per annum on each Ordinary share, provided the reserve fund was not increased. Then, I say, I believe there is room for reduction in some of these expenses. I am not speaking from a mere outside point of view. I have carefully gone through the last six balance-sheets. We are paying tremendously for ships. We are paying now about £37,000 for the costs of these two ships. Would it not be possible to save £5,000 or £6,000 out of that? The chairman himself in his last speech said, "The costs of our ships are very difficult to control; it is the only part of our expenditure I have any doubt about." He admits he has a doubt about it. If there is any doubt, and £5,000 could be saved, it would give a filip to the property. It seems to me the general expenses, £3,000 a year for just a staff and office in London is rather heavy, considering there

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is no dividend. If we had a dividend I would not criticise it. The working expenses of the twenty-two stations, £15,000—well, I do not suppose you can save very much there. You might possibly make a slight reduction, but not much. I do not like approaching the next question, but when the shareholders are getting absolutely nothing, when £80,000 to £90,000 is lent at 2 per cent., and we are left out in the cold, I think it is almost too heroic policy for the shareholders to adopt, and at the same time pay such very large fees to the directors. If we were dividing money I would double your fees, but while we are getting nothing it would be heroic on the part of the directors to say "We will suffer with you; we will leave our fees for the present until we show you a good result." Your property is much better to-day than it has ever been for years, and yet the market price is lower than it ever was before. I am satisfied that if this incubus was cleared off the whole of the securities of the Company would be on a much better footing, and would be saleable at three or four times the present price, and if the directors did want a reserve fund we should put our hands in our pockets and subscribe more capital. I would myself if I saw the interests of the shareholders would be served. I do not wish to move any amendment, but I would ask the directors as a favour if they will allow the meeting to be adjourned for a fortnight, so that the opinion of the shareholders generally may be taken on this important point. We are long suffering shareholders; we deserve some consideration, and I am sure that a scheme of this kind is commercially the proper thing, and it is only the apathy of the shareholders that has allowed the Company to dwindle down to its present position, which is not warranted by circumstances.

Mr. W. Abbott: I do not know that the hon. proprietor has asked any particular question he desires to be answered. I think his address was somewhat inconsistent. He congratulates the shareholders on the improved position which the Company occupies to-day compared with what it did at a period of its history which I well remember, but he immediately proceeds to the policy of improving that position by reducing the fees of those gentlemen who have brought the Company into its present state. Now I think that is not a policy which will find much support either in this room or by the general body of proprietors. I am pleased to say that I was the means of forming this Board, and I am pleased to think that there is no other telegraph Board in this City of London that possesses such varied experience and such an amount of ability in telegraph matters as the Board of this Company. To that experience and ability is due the position which you occupy, and the reserve fund, which I look upon with a great deal of jealousy, has been built up during a period of extraordinary pressure. You have got that reserve fund; it is a nest egg which will act as a reflex of your credit in any negotiations which you may have to enter into with the various Governments in the West Indies, and it will form a very substantial support to any scheme of reorganisation which the directors may see fit to propound a little later on for duplication of a portion of the system by which this very large expense of £30,000 a year, or 5 per cent. on £600,000, may be saved. I have persistently advocated in this room that you should, at as early a date as possible, make an effort to duplicate your system and save that expense. That £30,000 a year going out does not give any satisfaction to the shareholders, it does not give satisfaction to the colonial authorities, and it does really very little good, but it cannot be helped under the present circumstances; therefore, with the first gleam of daylight, and the better disposition of the colonies towards us, I do hope that opportunity will be taken to introduce a scheme for the reorganisation of this Company, backed by the assistance of the colony, backed by your reserve fund, and perhaps by a contribution by the shareholders, which, however, I think may be avoided. Now, I think, Mr. Chairman, as I have often told you before, you are not by any means a sanguine man. I have never known you speak in a sanguine manner before, and I think those few words you have mentioned to-day ought to carry more weight in the minds of the shareholders than if they came from an ordinary chairman. I think you are an extraordinary one. I was sanguine at one time, you were the reverse; you were right and I was wrong. Now that we are in a better position I do hope that you will take into your consideration that any spasmodic patching up of this Company should be avoided, and the next measure should be a comprehensive one. You state you are told by the colonial authorities that your capital is too large. It may be wise to reduce that capital, as, in fact, the £10 shares are about £1; whether they stand in our books at £10 or £5, does not much matter to the shareholders. That is a question which you will also no doubt take into your consideration. I hope, sir, the time is not far distant when some such scheme will be propounded, and I am certain, speaking for the body of proprietors, you will have our hearty support [cheers].

Mr. Prust asked how it was that they were only getting 2 per cent. on their reserve fund. He thought that the directors should take into consideration the position of the shareholders and consent to a reduction of their fees.

Mr. Newton pointed out that it was an absolute impossibility to capitalise arrears of Preference interest, and they could not do it even by liquidation, because it would be necessary to have the written consent of every individual shareholder, and in the present state of the law executors representing estates could not give that. The chairman would confer a great benefit on the commercial community if he could get the law altered in this respect. He thought that this at once dispelled the ideas that had been enunciated in the circular that had been issued to the shareholders. One thing he commended in the circular, and that was that Mr. Duncan had signed his name to it.

Mr. Robinson Kendall pointed out that, although they had a reserve fund of £80,000, the new cable which had been ordered would have to be paid for.

The Chairman, in reply to the questions, said that it would be a most unwise thing to distribute the reserve fund amongst the Preference shareholders in payment of their arrears of dividend. He thought that if they attempted to do it they would have an injunction from some shareholders to restrain them from carrying out the operation. He referred them to what had happened in the case of the Brazilian Submarine, which company had been obliged to apply the whole of its large reserve fund of £400,000 and borrow money besides to provide for the duplication of its cable. It must be borne in mind that this Company had no less than 4,000 miles of cable, and it was absolutely necessary to have a reserve to meet any accident that might happen to that. As to the loans on securities, when they did not want the money they lent it out on the Stock Exchange, and the rates varied. The money had not been out for the whole of the period, and they were going to invest it now in some substantial securities. As to the question of fees, he had often said that he was not anxious to be on the Board. The present directors were asked to join the Company ten years ago, when it was in a great mess, and the arrangement made he looked upon as a sort of contract with the directors. He did not believe he was paid more than the chairmen of other companies. He was perfectly willing to place his seat at their disposal, but as long as he remained there he did not see why he should not draw his fees, and he believed most of his colleagues thought the same. If they could get other directors to manage their affairs the present Board were quite willing to assent to any such arrangement. He was constantly in the office, and every director was near at hand, and frequently at the office. They had the experience of gentlemen who managed telegraphs on shore and on land from the time telegraphs had been made. They had the greatest concourse of experience on this Board, and they could not expect gentlemen to leave their other employment, and spend their time in looking after the affairs of this Company, with the conception of which they had nothing to do, for no remuneration. With regard to the proposal made to the Secretary of State, to which allusion was made in the report, they had no further information to give on that matter. With regard to Mr. Abbott's remarks, it was possible that the time might come when they would have to consider a reconstruction, and then all these questions would be treated, and the Company might take a new form; but, at any rate, it would be impolitic to move in any of these directions until they had got into more settled relations with the colonies than they were in at present. As to their expenditure, he thought that that would compare most favourably with that of any other company.

Major Wood said that he had had some experience in the management of telegraph companies with a large number of stations, and it was a matter of wonder to him and others how the directors managed with so little money. He thought that gentlemen who knew the real difficulties that beset the working of a large concern with a number of stations in the colonies would congratulate themselves at the smallness of the expenses.

The Chairman said that that remark was satisfactory after gentlemen had come there without the slightest experience and found fault with the directors for extravagance. There was no company, except perhaps the West Coast of America, that was so economically managed; but in the West Coast of America the circumstances were so different that it was difficult to make a comparison.

The motion for the adoption of the report was then put, and carried unanimously.

On the motion of Mr. Abbott, seconded by Mr. Robinson Kendall, a vote of thanks to the chairman and directors terminated the proceedings.

COMPANIES' SHARE LIST.

TELEGRAPHS.

Companies.	Closing Prices Oct. 31.		Business Done Week Ending Oct. 31. Highest.	Lowest.
Anglo American	44½,	45½	45½	—
Do. Preferred	75,	76	76	74½
Do. Deferred	15,	16	16½	15½
Brazil Submarine	9½,	9¾	10⅛	9½
Cuba	10½,	11	10⅞	—
Do. Preference	17,	18	—	—
Direct Spanish	5½,	5¾	—	—
Do. Preference	15½,	15¾	15½	—
Direct United States Cable	11,	11¼	11 9-16	11 3-16
Eastern Telegraph	10¾,	11	11	10 3 15
Do. 6 per Cent. Preference	13,	13½	13½	13¼
Do. 5 per Cent. Debentures, 1899	104,	108	—	—
Eastern Extension	11½,	11¾	11¾	11⅝
German Union	10,	10½	—	—
Globe Telegraph and Trust Company.	7¼,	7¾	7 7-16	7 5-16
Do. Preference	12¾,	13¼	13	12¾
Great Northern	12¾,	13¼	—	—
Indo-European	31,	32	31½	—
Mediterranean Extension	1¼,	1¾	1½	—
Do. Preference	2,	4	—	—
Reuter's	8½,	9	—	—
Submarine	210,	220	218	214
West India and Panama	1,	1¼	1 3-16	1 1-16
Do. 1st Preference	7,	7½	7½	7
Western Brazilian	5,	5½	5½	4¾
West. Union 7 per Cent. 1st Mortgage	122,	124	—	—
Do. 6 per Cent. Sterling Bonds	100,	103	—	—

TELEPHONES.

Consol. Telephone and Maintenance	¼,	⅜	⅜	5-16
Oriental	¼,	½	—	—
United Telephone	8,	8½	8½	8⅜

ELECTRIC LIGHT.

Anglo-American Brush Lgt. (£7 paid).	2½,	3	2¾	2⅝
Do. (fully paid)	4¾,	5¼	4 9-16	4⅝
Hammond Light (£3 15s. paid)	3¼,	3½	3½	3 1-16
Eastern Electric (£4 paid)	1⅜,	1⅝	—	—
Swan	1⅝,	1⅞	1 13-16	1⅝

MISCELLANEOUS.

Telegraph Construction	36,	37	36⅜	36¼
India Rubber, Gutta Percha, and Telegraph Works	30,	31	30¾	30½

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NOTES.

EARTHQUAKE IN GRANADA.—The Granada newspapers report that a slight shock of earthquake was felt in that city on Friday week.

A LOFTY POLE.—There is a telegraph pole in Cobourg, Ontario, Canada, which is 68ft. long. It belongs to the Bell Telephone Company.

THE JABLOCHKOFF COMPANY.—A petition for the winding up of this company has been presented, and will be heard before Mr. Justice Pearson to-day (Saturday).

ELECTRIC LIGHTING AT BRIGHTON.—It has been decided by the London, Brighton, and South Coast Railway Company to light their new station at Brighton with the electric light.

EGYPTIAN STUDENTS.—According to a telegram from Alexandria four young Egyptians are on their way to this country with the object of studying telegraphy and engineering.

ELECTRIC LIGHT IN AUSTRALIAN MINES.—According to the colonial papers, the electric light has been introduced for the first time at the St. Mungo Mine, Eaglehawk, in the colony of Victoria.

EASTERN EXTENSION TELEGRAPH COMPANY.—The traffic receipts of this company for the month of October, 1883, amounted to £36,869, and to £29,925 for the corresponding period of 1882, being an increase of £6,944.

ELECTRIC MOTOR SYNDICATE.—A petition for the winding up of this company has been presented by Alexander Browne, of Leconfield, Highbury New Park, N., civil engineer. The petition is directed to be heard before Vice-Chancellor Bacon to-day (Saturday).

GREAT NORTHERN TELEGRAPH COMPANY.—The traffic receipts of this company for October, 1883, were £23,640. For the period 1st January to 31st October, 1883, they amounted to £215,320, against £203,575 for the corresponding months of 1882, and £201,359 for the same period of 1881.

NEW TELEPHONE COMPANY.—The McDonough Telephone Company has been incorporated in New York. The capital is 1,000,000 dollars, with the proviso that it may be increased to 2,000,000 dollars. The principal office will be in New York. The lines are to extend from New York to San Francisco, New Orleans, &c.

SOCIETY OF ARTS.—The 130th session of the Society of Arts will commence on the 21st inst., with an opening address from Sir William Siemens, the chairman of the society's council. At the ordinary meeting on December 19th, Mr. W. H. Preece, F.R.S., will read a paper on "The Progress of Electric Lighting."

CUBA SUBMARINE TELEGRAPH COMPANY.—The number of messages passing over the lines of this company during the month of October was 2,815, estimated to produce £2,700, against 2,172 messages, producing £1,986 in the corresponding month of last year. The traffic receipts for the month of July, estimated at £2,700, realised £2,755.

COMPANIES WOUND UP.—Mr. Justice Chitty has granted a supervision order in the case of the Brush Electric Light and Power Company of Scotland, the shareholders of which recently resolved to wind it up voluntarily. The same judge has also made a compulsory order for the winding up of the London and Provincial Electric Lighting and Power Generating Company.

TELEGRAPHIC EXTENSION IN CANADA.—The Canadian Government system is about to be extended to the north-west territories, the head-quarters being at Battleford. The completion of telegraphic communication between the north-west, the eastern portions of Canada, and Great Britain and the Continent will, it is thought, do much to promote the rapid settlement of outlying districts.

THUNDERSTORM.—A very sudden and severe thunderstorm occurred at Dover on Wednesday night, the weather all day having been calm and fine. About seven o'clock it began to rain, and shortly afterwards, without any previous warning whatever, extremely vivid flashes of lightning were noticed, followed by terrific claps of thunder. The storm continued upwards of half an hour, passing westward rapidly.

MEDITERRANEAN EXTENSION TELEGRAPH COMPANY.—On Saturday last, before Vice-Chancellor Sir James Bacon, Mr. K. B. Buckley applied for an order confirming the resolutions of the company to wind up voluntarily.—Mr. Marten, Q.C., and Mr. Northmore Lawrence, for the preference shareholders, asked for a supervision order, but the Vice-Chancellor declined to make any order, except that the costs of the petitioner and of all parties appearing should be allowed and paid out of the assets of the company in the voluntary winding up.

INTERCEPTING TELEGRAMS.—The case of intercepting sporting telegrams at Manchester, which we have already alluded to in our "Notes," has just been tried at the local assizes. William Brittain, newspaper publisher, has been acquitted, but the others have been sentenced as follows:—Lamb, telegraph clerk, and Henry Hulme, compositor at the *Manchester Evening Mail* office, to twelve months' imprisonment, and Garside, another telegraph clerk, to six months' imprisonment. The history of the case will be found in our "Notes" for the past two or three weeks.

THE TELEPHONE IN SOUTH WALES.—A few days ago the Post Office authorities opened a trunk telephone wire, for the use of subscribers to their system, between Cardiff and Swansea, a distance of 47 miles. The first trunk wire erected in this district was that between Newport and Cardiff, which was put up some two years ago. Now there are three trunk wires between these towns. In addition to this there is direct telephonic communication between Cardiff, Newport, Ebbw Vale, Blaenavon, Abertillery, &c., so that there is a continuous telephonic circuit in existence over a distance of 82 miles. It is said that no difficulty is found in talking over this length of wire.

THE VIENNA ELECTRICAL EXHIBITION.—On Saturday last the Crown Prince and Princess of Austria inspected for the last time the Electrical Exhibition, which was to be closed on the following day. His Imperial Highness, addressing the members of the exhibition committee, laid stress upon the great success of the undertaking, and expressed his warmest thanks to all the co-operators and exhibitors who by their efforts had rendered this success possible, adding, "It filled us with pride to have the help of all friendly nations, and perhaps of their most experienced men." After alluding to the interest shown in the exhibition by the large attendance of the general public, the Crown Prince concluded as follows: "We part with the consciousness of having honourably performed our task."

OVERHEAD TELEGRAPH WIRES IN WANDSWORTH.—At a meeting of the Wandsworth District Board of Works held last week a letter was read from the solicitor to the Post Office, suggesting, in view of the magistrate's recommenda-

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tion, that the officers of the board communicate with the engineer-in-chief of the Post Office with the view of arranging a meeting to settle the position of the posts and wires. Mr. Cutler moved, and Mr. Lidiard seconded, that this be referred to the General Purposes Committee. Mr. Pocock objected to any compromise. Only a few days ago a serious accident occurred from an overhead wire. Mr. Thomson urged the board to leave the magistrate to settle the case, so that the responsibility for future accidents should rest on the Post Office. The reference to the General Purposes Committee was carried.

Electric Light in Dundee.—In the early part of this week the department of Mathematics and Natural Philosophy in University College, Dundee, was lighted up for the first time with the electric light. The current is supplied by a Siemens dynamo, which is driven by a six horse-power Otto gas engine. The current is sufficient to maintain forty 100-volt incandescent lamps in parallel arc, or fifty in series of two each. Of these, 12 light the lecture room, 23 the laboratories, and five Professor Steggall's private room, while, when necessary, extra lamps, or an arc lamp (as may be required), can be thrown into circuit. At present Swan lamps of the new pattern are employed. The fittings and lamps were supplied by the Northern Electric Light Company, and the wiring, &c., was done under the superintendence of Mr. Lowdon.

Atmospheric Electricity.—Pike's Peak, one of the loftiest meteorological stations in the United States, has several times been the scene of some curious electrical phenomena. In the weather report of the United States Signal Service for August last we read:—"The observer on the summit of Pike's Peak reported that during a sleet and thunder storm, on the evening of the 4th, the anemometer cups revolved in circles of electric light. After a flash of lightning the light encircling the cups became dim, but would soon regain its former brilliancy. The observer states that, by holding up his hands, electric sparks would form on the ends of his fingers, and that his hair and clothing were full of them. A peculiar crackling noise was heard about the anemometer cups, and at the corners of the office building there were continuous sparks of bright light."

The Telephone in the West Indies.—Mr. A. W. Gray, the general manager of the Tropical American Telephone Company, seems to have done a good stroke of business in the West Indies. He has already established telephones in Trinidad and Barbadoes, and when last heard of he was at Georgetown, where it seems he had been forestalled by the local Postmaster-General, who was about to set up the "Ader," a French modification of the instrument patented by the Bell Company. As the tropical company had bought all the rights of the Bell Company, and claimed the exclusive right of establishing telephones of this class in the colony, Mr. Gray was naturally anxious to know something about the modification in the Ader, which took it out of the category of the Bell system. The question was occupying the attention of the parties concerned when the mail left.—*Colonies and India.*

Societe Internationale des Electriciens.—We would remind our readers that the first meeting of this society will be held on the 15th inst., in the hall of the Société d'Encouragement, &c., Paris. Up to the present time no less than 900 members have joined the society, representing twenty different nationalities. Amongst these we find the names of MM. Digney, L. d'Arlincourt, Hughes, H. Pellatt, Sir Chas. Bright, A. L. Ternant, Sir William Siemens, W. H. Preece, J. M. Colette, Dr. O. Frölich, Raffard, Robert Sabine, Shelford Bidwell, De Mersanne, A. de Païva, Ch. de Comberousse, Latimer Clark, Lorenzetti, Ch. Porgès, Coumbary, Bourdelles, F. Bolton, Ch. Garnier, Sir W. Thomson, De la Taille, C. et E. de Ordunia, A. de Béjar, C. H. Gray, P. Willière, &c. Applications for membership should be addressed to M. le Président de la Société Internationale des Electriciens, Rue de Grenelle No. 99, à Paris (Ministère des Postes et Télégraphes).

Conversazione.—On Thursday evening in last week the annual *conversazione* of the Society of Telegraph Engineers and of Electricians was held at the South Kensington Museum. The guests, who were numerous, were received by the president of the society, Mr. Willoughby Smith. This year's *conversazione* was marked by two innovations, both of which were welcome. In the first place, ladies were invited for the first time in the annals of the society. We are inclined to look upon this new departure with very favourable eyes. After all, *conversaziones* partake more of the character of social meetings than anything else, and a good sprinkling of the fair sex amongst the men is to be welcomed and certainly makes the evening less dull and slow. Secondly, there was no electrical apparatus on show. For those who wished, however, there were the various sights of the South Kensington Museum. A good band played selections of music during the evening, and altogether the 1883 *conversazione* of the society was a most successful affair.

Balloons and Electro-motors.—With reference to the recent experiments of MM. Gaston and Albert Tissandier at Paris, we learn that M. Senlecq, of Ardres, well known to readers of this journal in connection with the telectroscope (*vide The Electrician*, Vol. VI., p. 141), has devised a plan not only of guiding balloons, but also of maintaining them at any desired elevation. A description of this plan was presented to the Academy of Sciences, Paris, on the 27th August last. The balloon is of the same shape as that used by MM. Tissandier, which by the by was first devised, we believe, by M. Dupuy, of Lome. M. Senlecq makes use of an electro-motor and helical screws of light material, the one to guide the balloon, and the other to cause it to ascend or keep it in any fixed position. To the car are also fixed a parachute to lessen the force of descent, and a large sail, whose function is to keep the balloon before the wind, or to cause it to deviate from the line of the wind as may be required. We do not know whether M. Senlecq has yet made any practical trial of his apparatus.

Cheap Telegrams.—In a recent issue of *The Times*, Mr. William White supports Lord John Manners's objection to making a charge for addresses. He states that "a message was sent from the Cape, costing £4 11s., addressed 'White, Wimpole-street, London.' It was not delivered from 'insufficiency of address.' My name having been in the same place in the 'Post Office Directory' for more than 25 years, during which time considerably more than 50,000 letters must have been delivered at my door, and there being no other of the same name, though such a common one, in the same street, it certainly seemed to me hard that it should not have been delivered. Its fresh transmission, including the number of my house, would have cost a further £5 10s., and my correspondent had to wait for regular postal communication. I could obtain no assistance from the authorities towards the reimbursement of the sum thus lost. The department shielded itself under its irresponsibility, but at the same time excused itself under the plea of 'pressure of business,' with the further explanation that deliveries were made not by the regular postman, but by boys, who had no time to search the 'Directory.'"

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The Liability of Telephone Companies.—In the City of London Court on Tuesday, before Mr. Commissioner Kerr, a question was raised in the case Velock *v.* the London and Globe Telephone Maintenance Company. The plaintiff carried on business in the City as a wholesale mantle merchant, and claimed damages in respect of damage to a quantity of ladies' ulsters through the alleged negligence of some of the defendant company's servants. It appeared that on the day in question the defendants' men were fixing wires on the roof of the plaintiff's premises, when, through carelessness, some of the bricks and mortar of the chimney stack were knocked down into the plaintiff's show room, and did the damage complained of. For the defence the defendants' superintendent was called, and said he visited the plaintiff's show room upon complaint being made, and inspected the goods. They were but slightly damaged, and for that the company had paid £2 into court as sufficient to satisfy the plaintiff's claim.—The Commissioner: Well, that is an admission of the company of their liability. I cannot decide the question of damages the plaintiff is entitled to, but, by consent of the parties, will send that to a reference. The amount of damages was referred.

Liverpool.—The Watch Committee have recommended that the tender of the Lancashire Maxim-Weston Electric Company to provide, fix, and maintain twenty 1,600-candle arc lamps in Castle-street, Lord-street, Church-street, Parker-street, Clayton-square, and Elliot-street, from dusk until midnight, and ten 1,600-candle arc lamps from midnight to sunrise, at 4d. per lamp per hour for twelve months, be accepted. The city engineer (Mr. Dunscombe) has gone into the question of the erection of the electric light apparatus without disturbing the pavements, and his report will be submitted to the council at the same time. He finds that it would not be practicable to lay the cables within the lines of the sewers, and connect the same with the lights on either side, because the sewers are not continuous along the streets which it is proposed to light, and connections with the electric light posts would in many cases involve more or less interference with the carriageway and foot pavements. As regards the number of hours during which the electric lights should remain, Mr. Dunscombe states that if the whole of the lamps were turned out every morning, say, at 12:30 a.m., it would be very doubtful whether any reduction in the annual cost of the gas lamps could be obtained, owing to reduced consumption of gas; inasmuch as such an arrangement would entail additional provision for lighting the lamps. It would therefore be advisable, he considers, to arrange with the gas company for the total discontinuance of the gas lights in the streets to be lighted by electricity; and, in addition, to specify what number of electric lights of a lesser candle-power should be maintained from 12:30 a.m. to daybreak. The probable cost of the electric lighting on the basis of the offer of the Maxim-Weston Electric Company will be as follows:—Twenty lamps, lighted until 12:30 a.m., 1,803 hours at 4d., £601; nine lamps of 1,600 candle-power, or their equivalent, maintained from 12:30 a.m. to daybreak, 1,817 hours at 4d., £272 11s.; total annual cost of electric lighting, £873 11s. This is said to be about three times the cost of gas as at present supplied.

titution of Civil Engineers.—With the commencement of a new session the institution issue a list of the subjects on which they invite original communications, for which, if thought of sufficient value, they will award premiums. Among these subjects we notice, "Mechanical Power on Tramways, including Steam, Compressed Air, Electricity, Cables, &c."; "Electrical Conductors"; "Electromotors, their Construction, Efficiency, and Power"; "Gearing for Dynamo Machine Motors, and other High Speed Machines"; "Transmission and Distribution of Electricity over Large Areas for Lighting and for Motive Power, including Electric Railways, Hoists, &c."; "Electrical Measuring Instruments"; "Submarine Telegraph Cables, their Manufacture, Laying and Repair, including Deep Sea Sounding Methods and Appliances"; "Telpherage, or the Automatic Electrical Transport of Goods and Passengers"; "The Measurement of Work by Dynamometers, with Descriptions of the Apparatus." There are certain instructions with regard to the mode of writing these communications which can be had of the secretary on application. We notice that one of the earlier papers fixed for reading at the institution meetings is one on "Electrical Conductors," by Mr. W. H. Preece, F.R.S. The course of lectures on the "Practical Applications of Electricity," delivered this year, was so fully appreciated, that it has been decided to have another series in the coming session. This will be on "Heat in Its Mechanical Applications." The lectures will be delivered on Thursday evenings, at 8 p.m., in the months from November to April, as under:—Nov. 15, "The General Theory of Thermo-dynamics." By Professor Osborne Reynolds, F.R.S.—Dec. 6, "The Generation of Steam, and the Thermo-dynamic Problems Involved." By Mr. W. Anderson, M. Inst. C.E.—Jan. 17, "The Steam Engine." By Mr. E. A. Cowper, M. Inst. C.E.—Feb. 21, "Gas and Caloric Engines." By Professor Fleeming Jenkin, F.R.SS. L. and E., M. Inst. C.E.—March 20, "Compressed Air and Other Refrigerating Machinery." By Mr. A. C. Kirk, M. Inst. C.E.—April 3, "Heat Action of Explosives." By Capt. Andrew Noble, F.R.S., M. Inst. C.E. Admission to these lectures will be as to the ordinary meetings of the institution, that is to say, members, associates, and students will have the right of personal admission, and every corporate member will have the privilege of introducing one friend.

Carbon Deposits in Incandescent Lamps.—In his inaugural address to the Newcastle-on-Tyne section of the Society of Chemical Industry, speaking of Dr. Fleming's experiments with Edison lamps, and the copper deposit which takes place in them (*vide The Electrician*, Vol. XI., p. 65), Mr. Barnard S. Proctor said, "In Swan lamps the globe contains no material but the carbon filament, platinum wire conductors, and an infinitesimal residuum of air. Dr. Fleming says that when carbon is deposited on the inside of the Edison lamp it is in a continuous coat, but when copper is so deposited the molecules appear to be thrown off in straight lines from the point of heated metal, so that a shadow of the carbon filament is thrown upon the opposite side of the globe, the shadow consisting of a line of clear glass upon which no copper has been deposited. In Swan lamps which I have had the opportunity of observing I have never seen such a shadow in either the carbon or the platinum deposit. My son, Mr. Charles Proctor, who is electrical engineer at the Swan Works at Benwell, informs me that these carbon deposits which occur when a lamp is overheated occur even more in lamps with the highest *vacua* than in those less perfectly exhausted. This would rather discourage the idea of the molecules being carried by currents in the residual air, and as yet we are wanting in evidence of the molecules being thrown off in radiations, and equally wanting in any indication of the carbon having been in a truly gaseous condition. As the highest temperature to which the carbon can be raised fails to give any appearance of softening, I think we must give up any idea of the bending noted in 1878 being consequent upon an incipient plasticity;

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and if the smoky deposit is supposed to be the result of vapourised carbon, we may also suppose that it cannot be melted except under the combined action of heat and pressure. Several lamps on the table illustrate the condition of the smoky deposit. There are four in which the deposit has accompanied the formation of an arc, and four in which the arc has not been formed, or the current has been stopped at the moment of its formation. In none of them can any symptom be observed which would indicate such a radial projection of molecules as to throw a shadow of the filament on the opposite side of the globe. There are also two broken globes, in one of which you may notice a patch of the deposit has been burned off by the heat of a spirit lamp, showing that the deposit is almost entirely carbon. In the other fragments the purple-black tint shows that an arc had formed by fracture close to the platinum wire, scattering platinum upon the glass almost free from carbon, as the film is little affected by heat, and almost entirely removed by *aqua regia*. These deposits have all been formed intentionally by passing through the lamps stronger currents than they were intended to carry."

Electricity and the Fire Brigade.—A correspondent sends us the following:—The application of electricity to the various uses of the Metropolitan Fire Brigade has of late made rapid strides. Every fire station in the brigade is in electric communication with the superintendent of the district station, either by telephone or telegraph, and that station in the same way is connected with head-quarters. The instruments used are the A B C Wheatstone, with alarms, every man in the brigade being able to use this instrument. A superintendent's station is quite a little electrical office in its way; rows of A B C instruments may be seen, with the name of the station to which they communicate engraved on a brass plate above each of them. In another corner are the various telephones, all likewise numbered and named. A little further to the left, and above the intruments, stands the fire alarm apparatus, and above the door the house bell and the station fire bell, both electric, the latter continuing to ring when once it is pulled until stopped by the man on duty. At the other side of the watch room are the electric bells communicating to the men's rooms, arranged to ring eparately or together by means of a mechanical arrangement and a single ring pull, thereby saving the few seconds wasted in ringing each bell separately in case of a call. Then there is the superintendent's office bell, and the electric gas lighter; and a little further on, and just above the speaking tubes, a dial which indicates which room the superintendent is then in. All these and many other contrivances for lighting the lamps, opening the doors, harnessing the horses, removing the steamer's gas jet, and turning up the gas, may be seen at most of the principal stations. Now, supposing there was a fire in Belsize Park, St. John's Wood Fire Station gets a call by a fire alarm fixed in Belsize-road. They turn out their engine, and telephone the call to Westminster, their superintendent's station. The station-duty man there enters the call in a book, touches a bell, looks at a disc, and tells the superintendent the nature of the call, turns round, pulls the ring in the bell box which wakes up the men, gets the engine away, and then orders on two or three more engines, and sends the call on to head-quarters by telephone. If a large fire, the man on duty there repeats the operations gone through at Westminster, touches a string which harnesses and frees the horses, lights the lamps, opens the doors, and in thirty to forty seconds a steam fire engine, with its full complement of men, has gone on to the fire, with fire lighted, and steam getting up. Besides the brigade instruments there are many private instruments and fire alarms at the fire stations, many of the theatres and public buildings having their own communication with the fire station, as also have some of the telephone exchange companies, thereby allowing their subscribers to give immediate notice of any outbreak. With these electrical and mechanical time-saving appliances, it rarely happens that, even in the middle of the night, more than two and a-half minutes elapse between the first note of the fire bell and the time that the men are on the engine, dressed, and ready to start.

Novel Application of Electricity to Mining.—A few days since a number of scientific gentlemen and others interested in mining assembled at M'Laren's Iron Foundry, Rotherhithe, to inspect a new process for separating metals from their alloys by electrolysis. Amongst the company were Mr. A. Zeehandelaar, commissioner for the mining territory of Utah, Montana, and Idalo at the Amsterdam Exhibition, Mr. J. Shealock, electro metallurgist, Mr. C. F. Jones, San Francisco, and Mr. Atkins, inventor. An elaborate apparatus was fitted up, showing the whole process at work, the power being obtained by two Gramme dynamos, assisted by accumulators. The alloy used was pieces of base bullion, composed of gold, silver, and copper, which were suspended in sulphuric acid, diluted with water contained in porous conductive vessels, with outer vessels filled with a solution of sulphate of copper, in which are suspended plates of copper. The alloy and the porous conductive vessels are connected by means of copper rods with the positive pole of the dynamo machine, and the plates of copper are in like manner connected with the negative pole of the same machine. The current of electricity being made to pass through the alloy enters the acid solution, which is thereby decomposed. The oxygen being liberated from the water combines with the silver and copper, producing oxides of those metals, which are soluble in the sulphuric acid, and the gold, being unaffected, falls to the bottom of the vessels, from which it is removed, washed, melted, and run into bars. The electric current passes from the alloy through the solutions and the walls of the porous conductive vessels to the plates of copper, at whose surfaces the hydrogen of the water combines with the oxygen of the sulphate of copper, thereby freeing the copper, which is thrown down in its metallic state. The metallic copper is then removed from the outer containing vessels, washed, and run into ingots in the usual manner. Fresh sulphate of copper solution is supplied to the outer containing vessels in a regulated stream as fast as the dilute sulphuric solution flows into the porous conductive vessels. The solution in the porous conductive vessels, when saturated with the sulphates of silver and copper, is withdrawn and run into a tank containing sheets of copper, which having a greater affinity than the silver for the sulphuric acid, the silver is thrown down in the metallic state, and the solution becomes one of sulphate of copper only. The pure silver, in a finely divided state, is then removed from the tank, washed, dried, melted, and run into ingots, and the solution of sulphate of copper is removed to the store tank, from which it is allowed to flow into outer containing vessels as required. It will thus be seen that the sulphuric acid in solution is used over and over again, and the metals separated from their alloy in a perfectly pure state. The advantages of this process over the systems now in use for refining are deemed by the inventor to be very great, it being almost automatic in its action, free from acid vapours in the atmosphere of the works, and economic in the use of acids. Further, the inventor claims for his invention that, instead of having to deal with the bye product, sulphate of copper, nothing but metallic copper is produced.

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UTILISATION OF NATURAL FORCES.

The letter on this subject from Mr. Volk, which we published last week, calls general attention to a question which has several sides, and which has interested a good many minds. The three "natural forces," as they are called, which are usually looked upon as available sources of energy, at present untamed yet inviting the control of man, are wind, waterfalls, and the tides. All these have long been used to a small extent as sources of motive power, waterfalls providing most. But there are numerous waterfalls not yet put into harness, because they happen to have been put into the wrong place, or rather perhaps because the places where men have chosen to plant their habitations, or find it expedient to plant their workshops, have been too far from these sources of energy. The same objection, amongst others, belongs to the tides, while want of uniformity in the quantity of work which Æolus chooses at any time to perform has greatly reduced the calls upon his services since the steam engine became common. The power derivable from both wind and tide are alike in this want of uniformity, for although tidal waters might be made to do work twenty-four hours per day, the means of obtaining this would be very costly. Hence, in order to make use of these so-called natural forces, some method of storage of energy has long been seen to be necessary. Something was required which would store up the excess of energy in times of high winds and during a part of each tide, and give it off as required or in uniform quantity. That something was not forthcoming, or it was thought not, and so the subject was tacitly allowed to sleep. Lately the storage of electric energy seemed to be possible. Attention has been thus redirected to it, but secondary batteries not being obtainable, thought has recurred to neglected means of storage, among them that which it is proposed by Mr. Volk should be tried. The proposals so frequently made since the applications of electricity have made such rapid strides, have had their origin in the facility with which electric currents may be transmitted over considerable distances, but finding that electric storage is not yet a practical matter, it has occurred to many that the modern facilities in the manufacture of pipes and air pumps might make proposals to distribute motive power by means of compressed air commercially possible, as well as practicable. Others have recurred to the distribution of power by means of water under pressure, regulated by service reservoirs and accumulators. Now we have Mr. Volk's proposal to make windmills drive dynamo machines, the current from which is to be utilised in the electrolysis of water for the production of hydrogen and oxygen to be stored under pressure and made to drive gas engines.

We may perhaps usefully say a few words on these proposals. The controlling element in the consideration of their practical realisation is the question of cost. We have in a previous article pointed out the only way in which the tides, where they are not of such exceptional rise as in the Severn, could be made to give off continually a uniform quantity of power. A few figures will be useful to show that except where the natural formation of the shore provides the means of making large reservoirs at moderate cost per ton of water impounded, even tidal energy cannot be economically used until some secondary means of storage has become practicable. One horse-power per minute equals 1,980,000 foot-pounds per hour, or nearly 16 millions of foot-pounds in eight hours, and it would be necessary to have reservoirs capable of containing a supply for at least one-third of the 24 hours in order to insure uniform power. This would be equal to 7,140 tons of water, or 254,000 cubic feet. This must be increased to allow for losses, including the difference between the net foot-pounds of work in the water and that given off by the best turbines. Taking the efficiency of the latter at 70 per cent., it would require at least 360,000 cubic feet falling one foot to provide one horse-power. Assuming an average available tidal head of 6 feet, then 60,000 cubic feet would be required per horse-power, or 6,000,000 cubic feet for 100 horse-power. With a depth equal to full tidal rise of 12 feet this would require a reservoir of 833 feet by 600 feet, and 12 feet in depth, or, better, two reservoirs of half that capacity. It is unnecessary to say that these reservoirs, with the necessary two duplicate sets of turbine or other water motors, would cost too much to allow us to consider this "natural force" available in place of steam power unless the reservoirs were to be found ready made in the form of a suitable estuary or low level inshore area of some sort. To build these reservoirs would cost probably £40,000. We may, therefore, conclude that in other than exceptional situations tidal power is not available for a continuous source of motive power. When, however, cheap practicable secondary batteries are to be had, the cost for electric lighting purposes may be very materially reduced, as one duplicate set of turbines could be employed, but it is questionable whether what could be saved in this way would not be more than equalled by the cost of the batteries. For large powers, such as 100 horses, the idea of using hydraulic engines worked by water under a high pressure is out of the question, and hence it is useless, were it not so for other reasons, to pump water to high elevations by tide mills in order to secure the storage of available energy.

For the same reason it may be said that the storage of energy by means of wind machines acting on pumps driving water into reservoirs is hardly to be considered, for, as will be seen, the reservoirs must be either large or high, and even to work hydraulic engines at least 3,500 cubic feet of water per horse-power per hour under 1ft. head, or 700 cubic feet per horse-power if at 50ft. head, would be required, making 35,000 cubic feet storage necessary to work such an engine of 10 horse-power for five hours. The use of compressed air is much more promising in some respects. One horse-power will compress about seven and a half cubic feet of air into about one-third that volume, or 2·5 cubic feet, and to a pressure of five atmospheres, per minute, or will compress about six cubic feet into a volume of 1·5 cubic feet, and a pressure of seven atmospheres or 105lb. per square inch. Of the work done in compressing this air about 50 per cent. can be re-obtained in the shape of work from an engine driven by compressed air. If, therefore, we use the higher of the two above-mentioned pressures, we require storage capacity in the shape of strong vessels of some kind, at the rate of three cubic feet for every horse-power of work to be done per minute. Thus, for 50 indicated horse-power for four hours, we should require accumulator receivers capable of storing somewhat over 36,000 cubic feet, while if simple receivers are used then about twice that capacity would be required to give a mean of half the above pressure for four hours, and the engines would have to be fitted with cylinders large enough to give off the necessary power, with air at the lower pressure. To hold this quantity say 85 vessels would be needed, of say 4ft. in diameter and 61ft. in length. Each of these would weigh over 5 tons, making in all about 450 tons. Storage by means of compressed air at a moderate pressure does not therefore promise much. Of course air at much greater pressure, say double, could be used, but the advantages are not altogether on the side of the higher pressures for working motors; even with a pressure of, say, 250lb., the storage vessels for four hours of 50 horse-power would probably weigh 250 tons, and the whole plant, including motors, compressing machinery, and storage vessels would be rather expensive.

We now come to Mr. Volk's proposal to obtain hydrogen and oxygen by electrolysis. Supposing the gas engines to be made by which this gas is to be converted into motive power, we have then the probable cost of the gas to consider. A current of one ampere will decompose 0·0000945 gramme of water per second, or 0·003462 gramme per hour. Thus a current of 1,000 amperes will decompose 3·462 grammes per hour, or 131,000 ampere seconds will be required to give 453·6 grammes, or 1lb. of hydrogen and oxygen, of which 0·889lb. will be oxygen and 0·111 hydrogen, so that 9lb. of water must be decomposed to get 1lb. of hydrogen. When obtained, hydrogen will give 62,535 units of heat in its combustion, representing 48,276,960 foot-pounds, and supposing one-fifth of this work to be obtained by a hydrogen-gas engine, rather a larger efficiency than is obtained with the best coal-gas engines, Mr. Volk would get 9,655,384 foot-

pounds of work done, or 4·8 horse-power for one hour. This, compared with the work done in obtaining the hydrogen by electrolysis, suggests that Mr. Volk has given very little consideration to this point. We may take it that 743 foot-pounds will decompose one grain of water and 743 × 7,000 × 9 gives 46,809,000 foot-pounds of work to be done in decomposing 9lb. of water; but this must be increased by an amount necessary to include the difference between the electro-chemical horse-power and the horse-power required to drive the electrical-generator, and this will bring it up to considerably more than the net foot-pounds in the pound of hydrogen. A generator would be required with an almost inappreciable resistance, and this possibly might be obtained, but a voltameter with an exceedingly small resistance is not so easily conceivable. Thus, for each horse-power expended in driving a generator for the electrolysis of water, Mr. Volk would, probably, get 10 horse-power from his gas engine. There does not, therefore, seem to be much promise in this new proposal for utilising "natural forces." Something might be said for the sources of energy which are in particular called natural forces, but the end of an article is not the place to be hypercritical as to terminology.

SOME NOTES ON THE HISTORY OF CABLE REPAIRING.

BY F. C. WEBB, M.I.C.E.

H.M.'s telegraph steamer "Monarch" has arrived in the Thames, and is being fitted with her cable machinery. The addition of another cable repairing steamer to the some thirty that before existed is not of itself a subject of great novelty, but this steamer is named after and replaces the "Monarch" steamer—or "Old Monarch," as she was familiarly called—which ship was the first of this line of useful steamers. When I say replaces I mean that she will be engaged in continuing the work which the old original "Monarch" was last employed on, namely, the repair of the system of cables belonging to H.M.'s Post Office Telegraphic Department. She thus replaces the first telegraph repairing ship that ever existed, and this forms an epoch in the history of submarine telegraphic engineering. The old "Monarch" was bought by the Electric and International Telegraph Company on the 14th of May, 1853, or more than thirty years ago. She was a paddle-wheel steamer, of about 500 tons, and was bought at Hull from Messrs. Brownlow and Pearson for £6,250. She was built in 1830. She served the Electric and International Telegraph Company until the transfer to the Post Office, and was then handed over to the Post Office and soon afterwards condemned. The first brake used in her for the laying of the Hague cables was fitted up by Messrs. R. S. Newall and Co. This was a drum brake with fleeting knife, which Mr. Newall had previously employed, and to Mr. Newall is distinctly due the credit of designing the first drum and knife brake. It was removed after the laying of the three first Hague cables, and one designed by myself permanently fitted by the company. This had a small improvement in the employment of three rollers to form the feed guide. The "Monarch" was chartered by Messrs. Newall and Co. for the picking up of the Donaghadee and Port Patrick cable, which had run short, and that firm made the first picking up gear ever used, consisting of *two grooved drums geared together* by a pinion and a bow sheave between two baulks of timber. Afterwards (in October, 1854) a picking-up machine, designed by me, was fitted permanently. This machine was different. It consisted of a *single drum with fleeting knife*, and this formed the first example of the picking-up machines which, with some improvements, such as overhanging drum and hauling-off gear, are used at the present day. A drawing of this machine is given in my paper read before the Institution of Civil Engineers on February 23, 1858. The first cable I ever repaired was one of the Hague cables, in August, 1853. It was not repaired in the "Monarch," but in the "Copeland" tug. The cable was found cut in two, just outside the shore end, off Scheveningen. This was the first example of a cable being repaired after being laid complete from shore to shore.

For four years afterwards various repairs were executed by me in the "Monarch," and one cable taken up and relaid at a greater distance from the others, and up to the time I left the company, in 1857, no other picking-up gear, I believe, had been made by any firm or company. During this time buoys, mushroom anchors, bridles, grapnels, &c., were employed by me, and the work of repairing thoroughly organised.

The next picking-up gear used were those made for the Atlantic Telegraph Company, from Sir Charles Bright's designs in 1857, and these were double drum machines, and were overhanging. In 1858 Messrs. Newall made a single drum machine, in the design of which I had some voice, Mr. (now Professor) Fleeming Jenkin making the drawings, calculating the strengths and arranging the details with great skill and judgment.

With this machine in the ss. "Elba" some very heavy cables were recovered in the Mediterranean by Messrs. Newall and Co., at which work Professor Fleeming Jenkin and I assisted. With this ship and machinery I afterwards repaired the Cagliani and Malta cable, about half way between the two places. This was the first cable repaired after being fully laid from shore to shore in the Mediterranean.

It was the experience of the casualties to which cables are subjected, and the knowledge of the means necessary for repairing them that caused me to insist so strongly in my evidence before the Committee of the Board of Trade, and since then in various articles, on the necessity of having repairing ships always ready to go to work, and of a duplicate cable to carry on the traffic when one is out of working order, steps which are now fully acknowledged as necessary to the permanent success of any submarine telegraph.

The Red Sea Telegraph Company of 1859 was the first company after the Electric Company to adopt the idea of a repairing ship, but not until too late, for the cables failed, and the company broke up before their vessel could be got away from England. The next permanent repairing ship to the "Monarch" I also had much to do with; this was the "Amber Witch." The Indian Government, on the advice of Col. Patrick Stewart and Messrs. Bright and Clark, included her as repairing ship from the very first in their programme. She was fitted with a picking-up gear, which I designed as chief of Messrs. Bright and Clark's staff. The drum was overhanging, and this was the first picking-up gear with single drum and knife in which the main drum is overhanging, and with an internal spur gearing to lessen the overhang by the width of the teeth. Overhanging drums are now used by the India Rubber Company, and by Messrs. Siemens, and were by Mr. Henley, but the Construction Company's machines have generally two drums, one for heavy work between the bearings of the shaft and another smaller and lighter one for light work overhanging the bearings. Mr. Henley was the first to make a paying-out machine with overhanging drum.

Bow sheaves have been much improved since the first one used by Mr. Newall at the picking up of the Donaghadee cable. That one was 6ft. diameter, and very narrow, and with wrought-iron spokes. The only guide for the cable was formed by the prolongation of the timbers beyond the sheave, and a bolt passed through to keep the cable in. In the "Monarch" I placed a wrought-iron guide shield under the timbers, afterwards replaced by a casting. Circular cheeks were used on the 1857 Atlantic cable. These followed the sheave round, which for a bow sheave I found dangerous, and made them vertical above the level of the shaft of the sheave in the "Resolute" in 1861. In fitting the "Amber Witch" in 1863, I countersank the sheave in the casting of the cheek. Double, and even treble sheaves are now fitted in some ships.

DIRECT SPANISH TELEGRAPH COMPANY.—The estimated traffic receipts of this company for the month of October, 1883, were £2,111, against £2,079 in the corresponding period of last year.

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CORRESPONDENCE.

DEFECTIVE DYNAMO.

TO THE EDITOR OF THE ELECTRICIAN.

Sir: May I venture to ask your advice upon the following :—

I have just finished a small dynamo with field-magnets of horseshoe section and Siemens H armature; but even at 500 revolutions it gives scarcely any result, no more, in fact, than when turned by hand.

The field-magnets' winding, tested by a compass, is correct, and the insulation throughout is good.

It is designed to run either "in series" or "in shunt;" in order to arrange the resistance on the field-magnets suitably there are two coils A and B. A consists of 50 yards 16 B.W.G. double cotton covered copper wire; R^A = about ·5 ohm, making about 50 turns on each leg. B consists of 300 yards B.W.G. 22 double cotton covered; R^B = about 9 ohms, and making about 280 turns on each leg.

For "series" these coils are coupled up in parallel, making R rather less than ·5 ohm. For "shunt" they are coupled up in series making R = about 9·5 ohms.

The pole pieces, cores, and sole plate, are of good soft cast iron, cast in one piece, which weighs about 25lbs. The sole plate is about $11'' \times 4'' \times \frac{3}{8}''$.

The armature is of good soft hammered wrought iron. Its effective part weighs about $4\frac{3}{4}$lbs., and is $9\frac{1}{2}''$ long and $2\frac{1}{8}''$ in diameter (the space between the pole pieces being $2\frac{7}{32}''$). It is wound with 40 yards of 16 B.W.G. double cotton covered R = about ·4 ohm, making 84 turns.

When coupled up "in series," and coil B connected with a two-cell grating gravity battery, it gives the best results, but they are extremely feeble.

The coils are well dressed with hot beeswax and resin.

Are the proportions of wire right? I can get no more wire of that gauge on to the armature; and I fear that more wire on the field magnets will be ineffective owing to distance from core.—Yours, &c., R. W. Oldham.

Wellow, Romsey, November 5, 1883.

ENDLESS CHAIN DYNAMO.

TO THE EDITOR OF THE ELECTRICIAN.

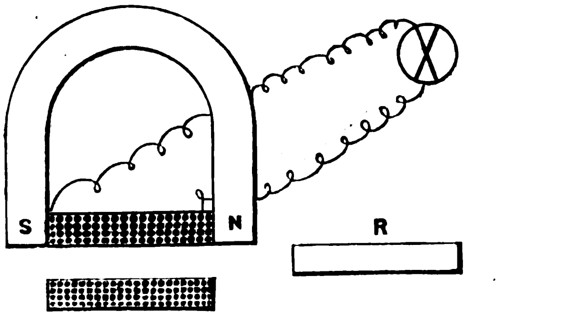
Sir: If Dr. Ermacora will refer to my last letter of Oct. 6 he will see that by crediting me with the invention of the endless chain dynamo he is misrepresenting me. Full particulars and drawings of the machine in question may be seen by referring to the Gramme American patent, No. 120,079. This machine, to work either as a dynamo or motor, does seem to be, and doubtless is, an impossibility. Dr. Ermacora thinks it equally impossible, "even if the chain is composed with alternate iron and non-magnetisable links."

Having had occasion to go to a factory some months ago, in one corner I saw a solenoid near to a six-cell bichromate battery. Whilst waiting, and when no one was looking, I placed the solenoid in a horizontal position, and put it in circuit with the battery. The internal diameter of the solenoid was $\frac{3}{4}$in., and its length about 5in. When a small rod of iron about 3in. long and $\frac{3}{8}$in. in diameter was offered to one of the openings, it rushed *through* the solenoid with considerable force, and by holding a plate of glass about a foot from the end of the solenoid, the rod in striking it made sufficient noise to attract the attention of the workmen, when my experiment ceased. Here, then, work was evidently done by moving the iron rod from one place to another, and by causing it to overcome considerable friction in its passage *through* the solenoid, and this without cessation or reversal of the battery current. I believe the reason of it is that the *polarity* of the solenoid tends to induce opposite polarity in the rod to that which is caused in it by the currents circulating in the solenoid (this action taking place *when the rod is moving*) it requiring more *time* to thoroughly alter its magnetic state than is allowed by the momentum it acquires on entering the solenoid. The polarity of the bobbin in this case acts precisely the same as permanent magnets placed at each end, but of course in a less degree. Dr. Ermacora thinks that if a permanent magnet were substituted for the solenoid the same result should be obtained. Although there is a wonderful analogy between a solenoid and a permanent magnet, there is nevertheless a distinct difference; for instance, a solenoid tends to induce, by its polarity, a pole of opposite sign, in an iron core, to that which is produced in the latter by the current, thus causing two opposed induced effects; but if a permanent magnet were similarly arranged with regard to the cord or rod there would be only one induced effect.

The movable iron rod or core may be identified with one of the links in the endless chain (supposing the latter consists of alternate iron and brass links), but Dr. Ermacora says "it suffices to observe that each link in crossing the two magnetic fields is effected in succession by two force integrals equal and opposite in sign." True, but whilst the link or rod is influenced by a magnet of one sign on entering the solenoid it acquires a certain speed, and when it advances far enough to be under the influence of the other inducing magnet its polarity is reversed. If a stone is thrown up vertically in the air there is a period when it is quite stationary before it commences to fall; and in like manner, in causing a magnet to change from N. to S., there is a period when it is neutral, and consequently demagnetised before it acquires the opposite sign. During the time these changes are taking place in the rod or link it is in motion, the result being that it is *less* magnetic as it passes out of the solenoid.

The power developed by a machine on this principle worked as a motor would be very little in proportion to its size, but if we consider it as a generator the case is altered.

Let the figure represent a solenoid fixed between the poles of a magnet, with a galvanometer in circuit. By thrusting the soft iron rod R into the solenoid the needle is deflected, and by drawing it out or by passing it right through the needle is deflected in the opposite direction. Evidently there is no such thing as coils cutting lines of force in this case,



the current being produced by the simple reason of iron being present in the solenoid. It is well known that the induced secondary current in a coil when contact is made and broken with a battery is greatly increased by inserting an iron core.

The dynamo which I have designed on this principle, and to which I made some allusion in my last letter, which you were good enough to insert, consists of segmental iron cores fixed to radial bars mounted on an axis. These movable cores are caused to revolve in fixed solenoids under the influence of field magnets, the action being in all respects similar to the above experiment.—Yours, &c.,

London, November 3, 1883. E. L. Voice.

CURING THE TOOTHACHE.

TO THE EDITOR OF THE ELECTRICIAN.

Sir: Referring to electricity as a cure for toothache by using a piece of zinc and a piece of silver, I have had the opportunity of testing it very often of late, and have found it very successful. I always used a half-crown for the silver. In the majority of cases the pain went away altogether, and in some came back after a day or two, but the sufferer was always glad to get even a day or two's respite. I think a good deal depends on what the aching arises from.—Yours, &c., C. M.

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With this week's issue we give an Index to the volume of which it is the concluding number. Our readers should see that they get this Index, for which no extra charge is made.

POLITICS AND THE SIXPENNY TARIFF.

Important as the subject is which gives the title to this article, we have almost to apologise for discussing it once again while it is still under the consideration of the Government. But a letter which appeared in *The Times* on the 30th ult., signed by the late Postmaster-General, and which we copied into our last week's issue, was a direct invitation to renew the agitation for cheap telegrams, irrespective of cost to the nation, and of convenience to the telepraphing public in general. As usual, there have followed a number of other letters from lesser personages who have crotchets to air, or who think their opinions on telegraph tariffs entitled to a hearing. Amid such a variety of counsellors it will be difficult for the Treasury to come to any decision at all, and quite impossible to arrive at one that will please everybody. We do not pretend to speak with high authority in this matter, but under the circumstances we do not scruple to criticise the critics who have had their say in *The Times* newspaper.

We lay claim to one qualification for performing this duty, namely, perfect freedom from party bias, a qualification which, we suspect, cannot be credited to all *The Times'* correspondents. No one would dream of accusing Lord John Manners of stooping to a political trick, and, indeed, the tone of his letter betrays the sincerity of his aims throughout; but it is difficult to avoid a suspicion that his lordship's opposition to the proposed tariff is just a little coloured by his opposition to the Government in power. We have the poor with us always, but the enthusiasm for their interests grows warmest in political circles when it coincides with the party interests of their friends. This would not matter so much in the present instance except that the cue may be taken by political followers so as to embarrass the Government very seriously. In other words, from the moment Lord John Manners' letter was made public there arose the danger that this question will be made a party one. It was a party manœuvre that carried the resolution of last March; but that was a trifle compared to the inconvenience which may arise if the merits of this and that tariff are to be weighed exclusively in party scales.

It is clear that Mr. Childers' "careful consideration" of what was involved in the acceptance of Dr. Cameron's resolution did not extend very far. It was proposed to set aside £170,000 out of his balance to enable him, if possible, "to carry out the change in the course of the present year." This was said last June; next June he will be no nearer carrying out the change than he thought he was then, though he will by that time have spent probably about three times the sum he originally named. The head of the department concerned, however, was better informed. £500,000 would be needed in the first instance to erect new main lines, which could not be completed, nor the other necessary preparations made, before October, 1884.

Evidently, then, there was a divergence of views between the Treasury and the Post Office, in the issue of which the latter showed its superiority. Now there is a divergence, if Lord John Manners' surmise is well founded, in which the present Postmaster-General figures as the poor man's friend whilst the Treasury stands guard over the public purse. "From his public utterances, no less than from the whole tenour of his administration, I feel confident of his sympathy when I deprecate, in the interest of the humbler class of the telegraphing public, the abolition, total or partial, of free addresses." So says the late Postmaster-General of his successor in office; and it bodes ill for the settlement of this question when appeals like that are made to the outside world. It is as good as saying, "I would have done so and so had I been in office; my successor would do the same if he had his own way. If he is prevented doing it, the Treasury—that is, the present Government—will be alone to blame, and the 'humbler classes' will thus know who are their real friends."

We say it reads like that: but of course his lordship did not mean that. He is sincerely attached to the free addresses, and really thinks their continuance, coupled with a reduction of prime cost, would be a boon to the poorer classes, whom he calls humble, but who, when their interest is in question, are far more importunate and impertinent than the class to which his lordship belongs. But what, in reality, does this plea on behalf of the humbler classes amount to? It is admitted they do not send telegrams now, but it is hoped they will do so if the price is reduced to sixpence—a pure assumption to begin with. But it is assumed also that "just in proportion as the senders and receivers are humble and unknown will it be necessary for them, in order to secure the delivery of their telegrams, to be liberal in paying for addresses." Now the real necessity, as touching persons whose addresses are unknown, will be for them to be less profuse in the text of their messages. This is an inevitable necessity attaching to any curtailment whatsoever of the system of free addresses; but it does not affect the humbler classes alone. On the contrary, it would affect the higher and middle classes chiefly, for they actually do send telegrams now, will send more when the cost is reduced, and their addresses are quite as "unknown" as those of their poorer neighbours.

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We have pointed out on several occasions that the balance is adjusted fairly by the circumstance that, whereas the commercial class whose addresses are brief require all the text you can afford them, the senders of private messages require very little room for text. Statistics will not help us much in a point of this sort, for of course there are a vast number of business and sporting telegrams that consist of very few words in all. But, appealing to one's own personal experience, we can all speak pretty positively as to the necessary length of most private telegrams. Twenty words, inclusive of addresses, would, in the great majority of cases, amply suffice for our personal wants, especially if the present practice of encouraging—and in some cases insisting upon—the insertion of the sender's address were discontinued. Lord John Manners too confidently asserts that there will be no sixpenny telegrams under any of the three schemes now being considered. If his prediction prove correct it will prove also that nobody wanted sixpenny telegrams, for there is nothing to hinder them, except in the pure fancy of his lordship that when the name and address have been written there will be no room left for the message. There certainly will be no room for the too common superfluities now thrust into the addresses, but their elimination will inflict no hardship on the classes who now thoughtlessly indulge in them, whilst it would afford immense relief to the traffic. It is said that the Government conferred the boon of free addresses when the transfer took place. This again is an error; the companies gave free addresses, not as a boon, but because they did not at first know any better. If ever they had combined to make any considerable reduction in the charge they would have conformed to the tariff which subsequent experience elsewhere has proved to be the only consistent and remunerative one, namely, so much for so many words, addresses included. A number of what may be called fancy tariffs have been lately suggested; but we must leave the consideration of these for a future occasion.

THE USE OF ACCUMULATORS FOR INDUSTRIAL PURPOSES.*

The experiments the results of which are given below were made with eight cells of the type used for tramway work. The total weight of the battery was about 30 kilograms, made up as follows :—

Boxes and contacts, &c.	6	kilograms.
Liquid (1 H_2SO_4 to 10 H_2O ...	6·500	„
Lead and oxides	16·800	„

The time at the disposal of the experts being short, it was thought that the most interesting question to study was the maximum work obtainable per unit weight of battery. Currents varying between 15 and 45 amperes were used, and though the experimentalists were unable to repeat the same tests several times, they came to the conclusion that the total available electrical work decreases at such a rate that a greater amount of work per unit of time is required.

The current measurements were made with a Siemens electro-dynamometer, the electromotive force being taken by a Thomson voltmeter. These were frequently tested during the experiments by Daniell cells. The accumulators were discharged through resistances consisting of German silver or thick copper wire, which had been verified both warm and cold. In this way the individual errors of each instrument could be eliminated. When testing a ton of accumulators, gross weight, viz.: box, liquid, plates, &c. combined, the following figures were obtained with a discharge of

13 amperes at start	...	15·6 electrical h.-p. hours.
24 „ „	...	12·5 „ „
44 „ „	...	11·5 „ „

With reference to the conversion of electrical energy into mechanical work and work into electrical energy, a number of experiments showed that under actual working conditions (1) The available electrical energy, measured at the terminals of the generating dynamo machine, reaches 70 per cent. of the mechanical work supplied by the motor which drives it; (2) that a dynamo machine working as a motor can transform into mechanical work the 70 per cent. of electrical energy which is furnished to it terminal to terminal.

The following figures are given as representing the mechanical work available per gross ton of accumulators :—

10·92 mechanical h.-p. hours	with 13 amperes	at starting.
8·75 „ „	„ 24 „	„
8·05 „ „	„ 44 „	„

According to the current used, therefore, we get :—

10·92 mech. h-p. hours	with 60 kgm. per ″	and per ton	or 8 h-p ″
8·75	do.	„ 111 „	do.	„ 1·5 „
8·05	do.	„ 203 „	do.	„ 2·7 „

These figures clearly show that the total amount of mechanical work which a given weight of accumulators can furnish is directly connected with the work required of these per unit of time.

The mean pressure (volts) at discharge during the experiments was about 70 per cent. of the mean pressure at charging. The mechanical work required in charging was calculated from these data. One hundred h.-p. of mechanical work supplied by a steam engine and applied to a dynamo, would give 70 h.-p. of electrical energy available in the external circuit for charging. Now, the quantity of electricity (coulombs) furnished at discharge is about 90 per cent. of the quantity of electricity furnished during charging if the two operations have been well carried out. The electrical energy available at discharge will be

$$\cdot70 \times \cdot90 = \cdot63$$

of the energy available for charging or

$$\cdot63 \times \cdot70 = \cdot441$$

of the mechanical work furnished by the motor. This electrical energy, available at discharge, transformed into mechanical work in a dynamo electric receiving machine, will furnish, by applying the co-efficient of transformation given above,

$$\cdot441 \times \cdot70 = \cdot3088,$$

or 31 per cent. of the initial mechanical work supplied by the motor. One mechanical h.-p. hour supplied by the accumulators will therefore cost 3·22 mechanical h.-p. hours supplied by the motor; or 100 mechanical h.-p. hours supplied by the motor will give us 31 mechanical h.-p. available for locomotion.

Regarding the first cost of charging:—Powerful steam engines well put down supply motive power at ·06c. per h.-p. per hour. One mechanical h.-p. furnished by accumulators will therefore cost in motive power

$$\cdot06 \times 3\cdot22 = \cdot1932\text{fr.},$$

or 20 centimes.

Regarding the first cost of electrical energy :—When accumulators are used for lighting purposes, it has already been shown that 100 h.-p. furnished by the motor produces 44·1 h.-p. of available electrical energy.

In point of fact, in this case this latter has not to be transformed into work. Each h.-p. hour of available electrical energy will cost 2·27 h.-p. at the motor.

Or 100 mechanical h.-p. hours furnished by the motor will yield 44·1 h.-p. of electrical energy available for lighting, at a cost of ·06c. per hour.

One h.-p. of electrical energy supplied by accumulators for lighting purposes will therefore cost in motive power

$$\cdot06 \times 2\cdot27 = \cdot1362\text{fr.},$$

or 14 centimes.

* Report to Le Genie Civil, by Messieurs E. Hospitalier, A. Fichot, and Léon Jousselin.

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THE INTERNATIONAL ELECTRICAL EXHIBITION AT VIENNA.

(FROM OUR SPECIAL CORRESPONDENT.)

IX.

We have already referred to the various incandescent lamps, more or less briefly it may be, but they have been mentioned by name. It is difficult to find anything new to say about most of these lamps. Every maker is constantly trying improvements, and attempting to get something that shall outrun all competitors, but as yet the better known lamps seem quite able to hold their own. Thus the Swan and Edison lamps are used far more than any others. We may point out here that there has been a gradual approximation of the Swan lamp in its important properties, such as E.M.F. required, resistance, &c., to that of Edison. It is probable that there would be little or no difficulty in a user of the one lamp replacing it by a lamp of the other maker, or in using the lamps indiscriminately. Perhaps they are not quite alike to allow of this, but the time is fast approaching when it will be done, if it cannot be done now. Here is a list of Swan lamps as made some six months ago, and the list could be considerably increased. In fact, we should imagine the ordinary type of lamp to be recommended now is the (nominal) 100 volt. 20 candle-power lamp :—

Class.	Volts.	Amperes.	Resist. Cold.	C.-P.
A_3	37	1·6	36	16
A_2	39	1·59	40	16
A_1	41	1·46	47	18
A_0	42	1·43	50	„
A	43	1·36	56	„
B_1	46	1·32	61	20
B	48	1·30	70	„
C	50	1·27	72	„
D	52	1·24	75	„
E	54	1·24	75	„
F	56	1·23	76	„
G	59	1·22	81	„
H	61	1·18	86	„
I	65	1·17	88	„

The present 100 volt lamp requires a current of about ·63 to ·65 ampere. We think the 100 volt lamps really require some five volts less—that is, should be used with an E.M.F. of about 95 volts. Taking the E.M.F., then, as 95 volts, and the current as ·63, we get 2·99 volt-amperes per candle-power, 100 volts and ·65 current giving 3·25 volt-amperes per candle. Not at all a bad result. The lamp I in table requires 3·8 volt-amperes per candle. It will be seen from the table that the normal candle-power of the Swan lamp is 20 candles. This light-giving power is kept constant, while the resistance, radiating surface, &c., is altered. In the more recent lamps for larger candle-power, however, the aim has been to keep E.M.F. constant while the candle-power varies. Thus, the 50, 100, and 200 candle-power lamps require an E.M.F. of about 105 volts. Taking the formula $C = \frac{E}{R}$, and keeping E constant, we see that C varies inversely as R, and the design being to have the light proportional to the current, we see that to double the current or double the light we must halve the resistance, and so on.

The higher candle-power lamps, 40, 50, 100, and 200, are so far, we think, purely exhibition lamps, showing what can be done if necessary, but, taking recently-published figures, these lamps are not so economical as the ordinary lamps. Thus,

C.-P.	Volts.	Amperes.	Resist. Hot.	Volt-Amp. p.c.-p.
50	105	3·25	32	6·8
100	105	6·5	16	6·8
200	105	13·0	8	6·8

Commenting on these figures, one of the correspondents* at Vienna says: "It is only a rough approximation to the truth to say that the light-giving power is strictly proportional to the current for the same electromotive force. The heat generated in the filament in the lamp is so, but the light radiated per second is not strictly proportional to the heat generated. On the supposition that this is an exactly true proportion instead of only a roughly approximate one, it may be interesting to show how the above mode of proportioning the resistance gives the required result.

"Let L represent the candle-power of the lamp, C the current, and R the resistance of the filament. We notice that, according to the proportions adopted in the design, $R = \frac{16 \times 6\frac{1}{2}}{C}$. Now the heat generated is proportional to $C^2 R$, and if H represent the heat generated in one second, in gramme centigrade degrees, $H = 0{\cdot}24\, C^2 R$. Therefore, $H = 0{\cdot}24 \times 16 \times 6\frac{1}{2}\, C$, or this heat is proportional to the current. According to the above figures, the proportion between the current and the candle-power is $C = \frac{6\frac{1}{2}}{100} L$.

"Inserting this value of C we get the proportion between the heat generated per second and the candle-power of the lamp :—$H = 0{\cdot}24 \times 16 \frac{6\frac{1}{2} \times 6\frac{1}{2}}{100} L = 1{\cdot}62\, L$.

"We have called this 'heat,' but it must be understood that it includes the energy given off as light. The whole of it is not given off from the surface of the carbon in form of heat, but is converted into light, that is, into visible radiating energy. What is not so converted is thrown off from the surface of the filament as non-visible radiating energy. If it were all given off as heat, and utilised to heat water by plunging the lamp in water, the number of grammes of water that would be heated in one second through one degree centigrade would be 1·62 times the candle-power of the lamp. This is the meaning of the above equation. Otherwise stated, the number of pounds of water heated one degree centigrade in three-quarters of an hour would equal the candle-power of the lamp.

"It must be understood, of course, that these figures apply only to the Swan lamp as above designed, namely, on the principle of using the same electromotive force for all sizes of lamps, and making the resistance vary by inverse proportion to the desired candle-power, so that the current varies in direct proportion to the same."

A good deal of what we have said of the Swan lamp applies to the Edison. A number of lamps were shown in coloured globes, in æsthetic surroundings, and so on, but the normal 16 candle-power lamp remains about the same, and is well known to all our readers. One great advantage the Edison had over the Swan was that the latter was merely a secondary exhibit by several exhibitors, while the former was shown by the Edison Company. Each lamp has its supporters, and this is as it should be, otherwise competition would be at an end.

The Bernstein lamp we have mentioned, and although the trials of the lamp by the jury are said to have been very satisfactory, and although attempts are being made to bring it before the notice of the English public in a commercial sense, our opinion is not shaken. As a lamp it may be all its supporters claim it to be; but for internal lighting we do not want a lamp the normal candle-power of which, when run economically, is from 50 to 100 candles. A lamp giving about 20 candles, more or less, is what is wanted. Some excellent advice was given by Professor S. Thompson, if we remember rightly, at his lectures at the Crystal Palace, as to the preference to be given to a moderate number of lamps of lower candle-power in a room rather than a minimum number of lamps of a higher candle-power. Unless the Bernstein lamps are used in series, the cost of conductors is prohibitive. If they are used in series, it involves the troubles arising from accident to one lamp affecting several others. True shunts might be used; but who is bold enough to advocate such a system in the present state of our knowledge? The Bernstein lamp is of hollow cylindrical network carbon, *a* in Fig. 1. This carbon cylinder is fastened to the conductors by pear-shaped knobs of carbon paste *b b*. The copper wires *c c* pass through an enamel bridge *d* and stem *e*, the one to screw *h*, the other to the ring *g*, connected to the globe

* *Engineer.*

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by gypsum *f*. The line wires are brought by suitable fittings into contact with *h* and *g*.

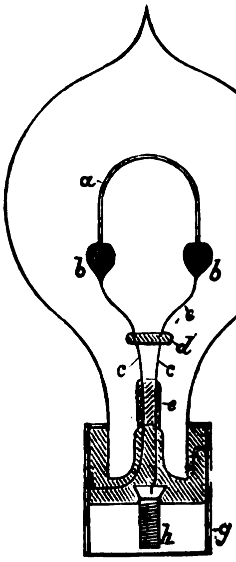

FIG. 1.—Bernstein's Incandescent Lamp.

M. Antoine Josef Gérard exhibited, among other things, an electric pen, an electric clock, dynamos, and a modified Swan

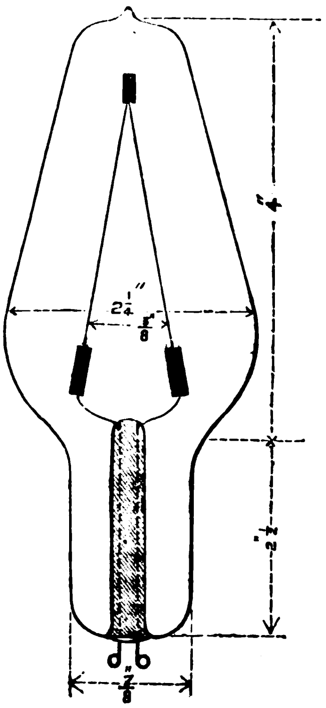

FIG. 2.—Gérard's Incandescent Lamp.

incandescent lamp. This lamp has straight carbons joined at the apex by a small lump of carbon, and by similar lumps

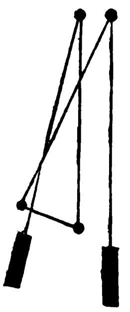

FIG. 3.—Arrangement of Carbons in Gérard Lamp for high candle-powers.

to the conductors (see Fig. 2). The conductors are led through an enamel stem to the terminals. For higher candle-power lamps the carbons are arranged in double pairs (*vide* Fig. 3). These lamps are designed—the former for 200 candles, the latter for 400 candles. The E.M.F. required is about 56 volts, a higher E.M.F. being used if the 400 candle-power lamp is used for a higher candle-power. The resistances of the lamps are respectively 8 ohms hot and 6·5 ohms, requiring currents of 7 and 8 amperes. It is really very difficult to say wherein such a lamp is new, but as it is so described, we must, of course, bow to superior wisdom. The carbons are those of Carré, but undergo a supplementary process of deposit of carbon from a hydro-carbon gas, a feature by no means new.

LITERATURE.

A Practical Treatise on Lightning Protection. By HENRY W. SPANG. With Illustrations. New and Revised Edition. [New York: D. Van Nostrand.]

It is refreshing to lay hands on a book, small or large, recently published on some branch of applied electricity other than electric lighting which also differs from these books on electric lighting in that it contains something original. We are not the favourites of the hack writers who compile pretentious books by means of paste and scissors, and who try to foist themselves upon the general public as authorities. So little do these men like us that they steal our articles, borrow our illustrations, even going to the pains to put the title of some other paper to the illustrations. We repeat, then, that it is refreshing to read a little work like this by Mr. Spang. He is not afraid to speak plainly as to his opinions, whether those opinions differ or not with those expressed by the authorities. The present writer is out of the pale of orthodoxy altogether on the subject of electrical repulsion. He does not believe in it, nor has his reading or experience ever shown him an experiment that proves repulsive action between similarly electrified bodies. He looks upon the terms repulsion and attraction as used somewhat conventionally, like the symbols + and −, and is ready to maintain that all electrical phenomena are to be explained as readily by attraction only as by the twin systems of attraction and repulsion. Hence he does not agree with Mr. Spang on this point, nor does he agree in the theory of the so-called return discharge. If Mr. Spang's illustration, p. 13, be examined, or any illustration approximately accurate showing the return discharge, it will be found that the configuration of the clouds or of the land surface is such that at these points the resistance between cloud and land is practically equal, and the discharge of the cloud or earth is from two points instead of one. That there is a flow of electricity to these points as indicated on p. 16, Fig. 5, is probable. The land or cloud just around the point or points of discharge, *i.e.*, around the points of least resistance, are acting exactly as the two metallic coats of a condenser, and accumulate till rupture or discharge takes place, and re-accumulate till the energy again overcomes the resistance, and so on till equilibrium takes place. Mr. Spang thoroughly understands this line of least resistance being the path of discharge, as may be gathered from his remarks on p. 18, "They offer the best route and the widest scope for the electricity of the clouds and earth to unite," "they" referring to animals on a plain, to masts of ships in water, &c. Directly Mr. Spang treats of practice he is on familiar ground, and his remarks are well worth reading. On the question of iron *versus* copper, he says:—

"Really the difference between the conductivity of copper and iron to the electricity in a lightning discharge is so small that it practically amounts to nothing.

"Iron is many thousand times a better conductor of the electricity in a lightning discharge than wood, brick, stone, and other material of poor conductivity, of which buildings are usually constructed, provided a sufficient quantity thereof is employed in a suitable form and placed in a short and direct route between the points of the discharge. Its advantages over copper are cheapness, greater resistance to mechanical injury, and high temperature of fusion (2·786deg. Fahrenheit as compared with 1·994deg. for copper). It is

also less tempting to the thief, who has on a number of occasions stolen part of the copper conductors erected upon buildings, thereby breaking their continuity and making the remaining portions useless."

We must quote also his description of an improved earth terminal. The illustration is not given, but any one can draw it from the lettering given.

"The improved earth terminal consists of a pipe not less than ten feet long, two inches inside diameter, and about one-quarter inch thick, made preferably of rolled iron in a single length, or two or more lengths, each about five feet long, with the usual opening at each end, and perforations or openings, P, along its length. The said perforations can be round holes, half an inch in diameter, or slotted openings, five inches long and one-quarter inch wide, and be placed at intervals of about ten inches from each other, preferably in two lines opposite each other.

"The pipe can be round, square, triangular, or any other suitable form; and instead of employing a solid pipe with perforations, curved, flat, or angle bars of iron can be employed and be attached at both ends, also the centre, to suitable metallic devices, so there will be suitable spaces or openings between the bars, through which the water can pass and moisten the surrounding earth, and answer the same purpose as a solid perforated pipe.

"A plate of rolled iron can be employed in the form of a pipe, with the longitudinal ends separated about a quarter of an inch, so that water can escape into the earth along its entire length, and also allow the pipe to expand when ice is formed therein.

"The pipe, C, can be driven into clay, sand, and gravel soil in the same manner as the pipe of a driven well is placed in the earth. A metal shoe with sharp edge can be used at its lower end instead of the pointed device used with the driven well pipe, and the earth removed from the interior of the pipe by means of a common screw auger of suitable diameter, which can also be used for testing the ground before driving down the pipe, and thereby avoid striking large stones or solid rock.

"Pipe C should be placed so that the waste water from a hydrant or pump in the vicinity of the building, and the rain water from the pipe A, flowing along the gutter or drain I, will readily enter it through its top opening, and passing through its lower and side openings, cause a suitable area of earth around and beneath it to become and remain moist during the whole year, and thereby effect an easy electrical path between the lower end of the pipe C and the subterranean water bed.

"Wherever convenient, the pipe C should be located not less than eight feet from the foundation wall of the building, so as to allow a suitable area of earth to be moistened, and prevent the said wall becoming saturated with moisture. In cities and towns it can be placed near the kerb line or in the street gutter; when employed in connection with the rain pipe, or other lightning conductor, along the front part of the building; and where the earth terminal must be placed within eight feet of the foundation wall of a building in order to be in line with the flowing waste and rain water along a gutter or drain, it is necessary to employ a solid pipe without perforations between the surface of the earth and a point about two feet below the surface of the cellar of the building, and a perforated pipe not less than six feet long below the solid pipe, and thereby maintain a suitable area of moist earth below the surface of the cellar and without saturating the foundation wall or walls of the building with moisture.

"Pipe C should, preferably, be set in the earth so that its upper end will be about six inches below the surface of the earth, so as not to be exposed to the rays of the sun and become greatly heated during the summer season, and thereby prevent the moist earth around its upper end being soon dried up. A suitable pipe, H, about four inches inside diameter and eight inches in length, can be placed around the upper end of the pipe C, but not in contact with it. Its upper end should be nearly flush with the gutter or drain I, or the surface of the earth, and contain a perforated screen, which will allow the water to flow readily into pipe C and around its top, but prevent the passage of trash therein, with which it might otherwise become filled.

"The top of pipe C can be set nearly flush with the gutter I, and be covered with a suitable screen, and thereby dispense with the pipe H, where the pipe C is not exposed to the sun or is required to be placed near the foundation wall of a building.

"In large cities the rain pipes upon buildings generally connect with and empty into drain pipes leading into sewers, which cannot be considered as reliable earth terminals, owing to the short depth they usually extend through the earth and its dry condition during the summer season. In such cases it will be necessary to place a perforated pipe not less than six feet long in the earth, with its top about two feet beneath the surface of a cellar, vault, or any other suitable place convenient to the drain pipe, and be supplied with water therefrom by means of an iron pipe about two inches outside diameter, which must be properly connected with the drain pipe, and tightly fit into the top portion of the perforated pipe, so that the water will readily flow from the drain pipe into the perforated pipe, and at the same time prevent the surface portion of the cellar or vault becoming saturated with water, as it is not desirable to have it in a very damp or moist condition.

"During the beginning of a thunderstorm, the water from rain pipe A, flowing along the gutter I, will soon fill the pipe C and H, and flow in a body over them, and establish an electrical connection between the top of pipe C, and the moist surface earth, which, together with the moist earth around and beneath the pipe C, will constitute easy paths for the electricity of the clouds and earth, while quickly uniting. Solid rock greatly impedes the electricity of a lightning discharge in its passage over the surface earth to or from the subterranean water bed, and to drill a hole in the rock so that an earth terminal can reach the water bed is rather expensive. The liability of damage to a building erected over a stratum of solid rock can be greatly lessened by providing it with a metal roof and connecting its rain pipes with earth terminals of suitable forms, each having not less than twenty square feet of surface, which should be placed vertically in the earth, as deep as possible, and with the top portions contacting with the rain water flowing along the gutters."

We have quoted enough to show that Mr. Spang has formed his own opinion, and we may say that not only that part of the book we have quoted but the remaining portion is very readable and interesting.

On Magneto and Dynamo Electric Machines. By J. A. FAHIE, Inst. C.E.I. Dublin: John Falconer, 53, Upper Sackville-street.

Mr. Fahie has in pamphlet form reprinted his paper read before the Institution of Civil Engineers of Ireland last December. The paper gives in handy form a sketch of the history and a description of the principal machines. It is illustrated, and will probably form a simple work of reference for those whose knowledge of the subject is limited but whose professional engagements now and again require some fairly trustworthy information in an easily accessible form.

THE TRANSMISSION OF ENERGY.*

BY PROF. OSBORNE REYNOLDS, M.A., F.R.S.

(CONCLUDED FROM PAGE 575.)

Lecture II. (Concluded).—Monday, April 30th, 1883.

One fact should be noticed, that in all these forms the power is packed, and needs nothing but drawing off, whereas corn or coal do not contain the power. The oxygen is an equally essential ingredient. In this fact lies the great advantage of corn and coal for transportation. They are really, so to speak, but cheques for power, which can be cashed at any spot where a bank, in the form of a steam engine or a horse, exists. But, of course, not being energy, they are not generally current—in fact, they are worthless, except where the bank exists, and where they represent such small amounts that the banks refuse them. Now, these forms of packed power are, so to speak, generally

* Cantor Lectures, reprinted from the *Journal of the Society of Arts*.

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current; that is to say, they are available under almost all circumstances, and in greater or less degrees of smallness; from the very smallest, which is the watch spring in our pockets, which supplies a continuous stream of power in less than one ten thousand millionth of a horse-power; or the Whitehead torpedo, which carries some million foot-pounds of energy under the sea. Perhaps the most pressing purpose for which these forms of packed energy are wanting is that of locomotion.

The distance which a locomotive body, be it animal or machine, can travel, loaded or free, is limited by the ratio of the power which it carries to its gross weight. The speed which it can attain is limited by the rate at which it can use its energy compared with its weight. Hence there are two particulars in which we can compare the different forms of stored energy for locomotive purposes.

Let us take the horse and the locomotive. A full-sized horse weighs, say, 1,500lb., and, at a rate of 2½ miles an hour, will go five hours without food, doing about ten million foot-pounds of work, including the work necessary to move itself; this represents the largest result, or about 150lb. per million foot-pounds. If the horse is put to ten miles an hour, it will not do more than 1·5 million foot-pounds in a single journey besides moving itself. Probably the greatest rate at which a horse can use its energy is about four million foot-pounds per hour, or 750lb. per horse-power.

A locomotive with its tender, say, weighing sixty tons, exerts 500 horse-power gross—270lb. per horse-power per hour; so that a first-class locomotive with tender is above one-fifth as heavy for its power as the horse; but then the horse cannot go more than ten miles an hour.

Now, in a general way, passenger locomotives carry coal and water for eighty or one hundred miles, *i.e.*, two hours; or the locomotive already mentioned expends at one run about two billion foot-pounds; which means that the gross weight of the locomotive is about 60lb. or 70lb. per million foot-pounds of power with which the locomotive starts.

In thus taking the gross weight of the horse or locomotive, we must remember that this includes the weight of carriage and machinery, and that in whatever form the energy is carried, this weight must be added. In the locomotive the weight of water and coal in the tender for two hours' journey weighs about one-quarter the gross load; and if we add the weight of the boiler, we may consider the carriage and machinery at one-half to one-third the gross load. Taking the latter, and substituting for the boiler, coal, and water, energy in either of the above forms, the coal, water, and boiler would be about 40lb. per 1,000,000; so that, if we took compressed air instead, we should have one-fourth the power; or the engine would run for thirty minutes instead of two hours, a distance twenty-five miles instead of a hundred. A fireless locomotive might do more than this, say, thirty-five minutes, or thirty miles, at the same speed as the locomotive. Faure's battery, if it could be made to work at all, would carry the locomotive forty-eight minutes, or thirty-five to forty miles.

These figures seem to show that the locomotive has little to fear from any of these rivals, that is under circumstances where the smoke and steam are no harm, and where a full-sized locomotive is required. But there are already some cases where the locomotive is required and where the burning of coal is impossible. Should the Channel Tunnel be made, there will be a great field for some form of packed energy; but it does not seem that the promoters have much faith in a smokeless means of working the tunnel being forthcoming. As regards horses, however, there is nothing to show why the horse should not be rivalled by some one of the forms of packed energy. There have been inventors who have constructed carriages to go by clockwork. This has now become possible, substituting hot water, compressed air, or a battery for the spring, and such means have already rivalled the horse on tramways. The fact that horses are at all used for tramcars is a matter of as much surprise as that steam should be used on underground railways. For locomotives driven by compressed air might certainly be made cheaper and better in every way.

At the present time it would probably answer well, in a pecuniary point of view, to supply in compressed air energy at the rate of 2d. or 3d. per million foot-pounds, provided a sufficient quantity could be required; so that if simple and efficient means of applying such energy to perform the heavier part of manual labour, we might get as much power for 6d. as what a man will do in a day at 2s. But it is the means of applying it that is wanting.

Even for horse work—except where there is a railway or tramway—the mechanical means are wanting. We have no mechanical substitute for the horse's foot. So that, although there are more than a million horses in this country continually engaged in the operations of husbandry, where they work in groups so as to get three or four horse-power at one operation, an amount of power not too small for the direct application of steam power, and although for twenty-five years steam-engine makers have been doing their very best to adapt the power of the steam-engine to this labour, which exceeds any other actual application of power, the possibility of steam ploughing with economy is still a question. The use of steam on paved or on macadam roads is much the same, so that, until steam has been applied to such purposes, there is little hope for other forms of stored energy.

Coming back for a moment to Faure's battery, I would carefully point out that the result which I have put down—100lb. per 1,000,000 foot-pounds of energy—refers to what has been already accomplished, and not to any possible limit. The principles involved in the chemical action of these batteries, in fact in all batteries, are well understood; and so far as these principles are involved, it is easy to define limits; but there are a number of secondary actions which are not so well understood, and which have hitherto prevented any approach to the theoretical limits. In the Faure battery, the theoretical limits are about 3lb. per 1,000,000 foot-pounds. That is to say, the oxidisation of 1lb. of lead to litharge, and the deoxidisation of 1lb. of peroxide, together, yield 360,000 foot-pounds. How far, at present, Faure's battery is within this limit, at once appears something like twenty-four times. Should this be accomplished, power could be packed at the rate of 1,000,000 foot-pounds for 3lb., or say 6lb. weight, to allow for wastes, a result which would most certainly displace steam in the locomotive, but which would still leave coal and corn six times the lightest vehicle of power.

It should be noticed, however, that although the means of doing so are still entirely wanting, could other metals, such as iron or zinc, be used instead of lead, the results would be much greater. This is shown by the relative amount of power necessary to oxidise or deoxidise these materials, which we see for iron and zinc are five or six times greater than for lead; here is an apparent opportunity for art.

Should this be realised, then, indeed, coal might be displaced as the cheapest medium for the transmission of power, but that would be a small matter compared with the change that would occur in our ways of applying power. For the dream of Jules Verne, of 20,000 miles under the sea, would become a reality, and, instead of steamboats, we should travel in submarine monsters as yet unnamed, which we may call steam-fish.

But if science as yet imposes no limits beyond those I have mentioned, at the same time it holds out no prospect. The chemistry of these batteries has been very deeply considered, and those who have studied the subject most deeply apparently see no direction in which to direct their efforts; so that any great advance in this art must entail a great discovery in science.

There now only remains for me to consider the transmission of power as power, or by electricity, a most important branch of my subject, which I must take in my next lecture.

Lecture III.—Monday, May 7th, 1883.

So far I have spoken only of the conveyance of power by means of coal, corn, or in one or other of the several forms of packed energy. To-night I come to consider the transmission of power by what are more distinctly mechanical methods, and by currents along pipes and conductors. These are the means by which power is almost always distributed, *i.e.*, transmitted from the acting agent, be it horse, water-wheel, or steam engine, to its operation, whatever it may be. In most cases the distance of such transmission is so short as to be the subject of small consideration in determining the means to be employed. That is to say, the means are chosen rather by their adaptability to receive and render up the power than by the efficiency with which they transmit it. Thus, if we take an ordinary mill, the shaft which receives the power from the engine is generally driven at that speed which is best adapted to receive the power from the engine, and deliver it to the machinery in the mill, without considering whether a much smaller shaft might be used if it were caused to run at a much higher speed. Thus, in a mill driven by an engine of two or three-hundred horse-power, the shaft which receives the power will generally be five or six inches in diameter, whereas it would be possible to use a shaft of two inches diameter if the efficiency of the shaft were the only consideration. Or, again, take a screw steamboat. The distance from the engines to the screw may be 250 feet, the power 10,000 horse. This could be transmitted by a shaft twelve inches in diameter, if allowed sufficient speed, but the screw has to make sixty revolutions per minute, and this determines the speed at which the shaft is made to run, and hence the shaft is made thirty inches instead of twelve inches. This is because, owing to the smallness of the distance, the efficiency of the means of transmitting the power is a small consideration. There are, however, many circumstances under which it is impossible to bring the source of power close to its work, and then

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either mechanical power is not used, or the efficiency of the means becomes a consideration.

In other cases it is a question whether it is better to distribute the sources of power, such as steam-engines, so that they may be near their work, or to use one large source and distribute the power by some mechanical means. This rivalry exists in almost all engineering work which covers a large area, and, generally, a compromise is come to, engines being distributed about the works, and the power of these distributed to the machines by means of shafting. In many cases separate engines are used for each machine, but not often separate boilers, the power being distributed by steam pipes.

Dockyards have long afforded a field for the competition of the various means of distributing power. Here, generally, the distances between the operating machines, such as cranes and capstans, is considerable, and the work required from each machine very casual. And every means of distribution is or has been in use, from a separate engine and boiler to each machine, as at Glasgow (separate engines drawing their steam from central boilers), to a complete system of hydraulic transmission from a central pumping station, as at Grimsby or Birkenhead.

But the question between centralisation or distribution of steam-engines is not by any means the only one, or most important one, which depends on mechanical means of distributing power. Every improvement in the means of distributing power from a central engine opens a fresh field for its use.

The considerations relating to this subject are numerous. Hitherto, as regards the main transmission of power, the principal consideration has been the percentage of loss according to the distance; but, as regards the final distribution of power, the form in which it is distributed must be such as admits of its being at once available for its purpose. Thus hydraulic distribution is favoured in dockyards, because it is required for heavy forces and slow motions, but where rapid motion is required, hydraulic distribution gives place to some other.

Again, where the quantity of power that has to be distributed is a most important consideration, the distribution by means of water or compressed air will generally be the most efficient, whereas these would be by far the most costly means for small quantities. It thus has to be remembered that, besides the general question of efficiency, each means has particular recommendations for particular purposes.

It is not, however, with these particular recommendations that I am concerned. My object is to show the limits within which the use of each means is confined, however fit it may be for its purpose. Taking first the mechanical means, which are shafts and ropes, we find that the possible limits to both these means are absolutely defined by the strength of material. The amount of power any piece of material will transmit by motion against resistance is simply the mean product of the stress or force acting in the direction of motion on the section multiplied by the velocity, so that, if the stress is uniform over the section, the work is the product of the area and intensity of stress and the velocity.

In a revolving shaft neither the stress nor the velocity are uniform over the section, both varying uniformly from nothing in the middle to their greatest value on the outside; so that their mean product is exactly half the product of the greatest values. The greatest power per square unit of section a shaft can transmit is half the product of the greatest stress into the velocity at the outside of the shaft.

Taking, then, the greatest safe working stress for steel at 15,000lb. on the square inch; taking what is the greatest practical velocity at the surface, 10ft. per second (the speed of railway journals); the work transmitted is 75,000 foot-pounds per second per square inch of section—135 horse-power; so that we should have to have a shaft of upwards of 7 square inches in section to transmit 1,000 horse-power, that is, a shaft of over 3in. diameter. The friction between such a shaft and lubricated bearings is well known, ·04; so that, calculating the weight of the shaft 24lb. per foot, we have power spent in friction about 52,000 foot-pounds per mile, that is one-tenth the total power the shaft will transmit. That is, if we put 1,000 horse-power into a 3in. shaft, making 500 revolutions per minute, we ought, at the end of a mile, to be able to take 900 horse-power out of it. If we had to go farther, the size of the shaft might be diminished, so that in the next mile we should again lose a tenth, and if we repeat this process seven times, we shall, at the end of seven miles, have left about half the original power put in.

It will be thought, perhaps, that a 3in. shaft is very small to transmit so large a force; this is because the speed of 500 revolutions per minute is inconveniently high for purposes of employing the power; but if it were merely a question of transmission, it would be about the best speed. This, then, shows the limit of the capacity of shafts as transmitters of work.

Turning now to steel ropes, these have a great advantage over shafts, for the stress on the section will be uniform, the velocity will be uniform, and may be at least ten to fifteen times as great as with shafts—say 100 feet per second; the rope is carried on friction pulleys, which may be at distances of five or six hundred feet, so that the co-efficient of friction will not be more than ·015, instead of ·04. Taking all this into account, and turning to actual results, the work transmitted per inch would be 1,500,000 foot-pounds per second; or that a ¾in. rope is all that is necessary to transmit 1,000 horse-power in one direction, this would make the loss per mile only 1-60th. But in practice, rope has to be worked backwards and forwards, and the tension in the backward portion of the rope must be half the tension in the forward portion. This reduces the performance from 1-60th to 1-20th, which would cause half the work to be lost in ten miles. If we use a bigger rope, and run at lower speed, then the co-efficient of friction would be reduced to 0·1, and the distance extended to fifteen miles.

Experience with ropes is large, and they have been found, without question, to have been the most efficient mechanical means of transmitting power to long distances, but their use is subject to drawbacks. The ropes wear somewhat rapidly, as do also the pulleys on which they run, and this circumstance is very much against their use in any permanent work; nevertheless, they are used for working mines, steep inclines, and steam ploughs, while at Schaffhausen they have been used for transmitting power to considerable distances.

Turning to the transmission of power along pipes, we find the conditions somewhat modified. The formula for the amount of power transmitted by water is the same, namely, the product of the area of section into the velocity, but the resistance obeys different laws. In the case of shafts and ropes we have seen that the distance is subject to an absolute limit.

In the case of fluid in pipes this is not so. No matter how long a pipe may be, if there is no leakage water would flow along the pipe until the level of its surface were the same at both ends, but the rate of flow would diminish with the length and diameter of the pipe. Thus we can transmit power through a perfectly tight pipe, however small and however long; but when we come to consider the gross power that can be transmitted through a given pipe, with a given percentage of loss, the question is different. Given the size and strength of the pipe, the gross amount of power, and the percentage of loss, and the limits are fixed. Thus, taking a 12in. pipe capable of standing 1,400lb. on the square inch, the loss in transmitting 1,000 horse-power would be about 5 per cent. per mile, at first increasing—as the pressure fell to 700lb.—to 10 per cent. We should thus have lost half the power in about seven miles. We cannot say that seven miles is the absolute limit, for with a 24in. pipe, which would cost four times as much per mile, we could transmit the same power thirty times as far with the same loss. The cost of laying a 12in. pipe for seven miles, however, would probably be as much as even 1,000 horse-power would stand; while a 24in. pipe for 200 miles would be out of all proportion. Then there is the consideration of leakage, which, although very small for short lengths, is larger for greater lengths.

Seven miles is at present an outside economical limit of hydraulic transmission, even for such a large amount of power; but with air the case is different. This flows so much easier than water, that the cost of transmitting the same power through the same distance, with the same loss, would be about 12 per cent., or, at the same cost per mile, the air may be transmitted 100 times as far with the same loss. The total cost, however, would thus be 100 times as great, which would exceed the economical limit; but not only theory but practice has shown that power may be economically transmitted five times as far by air as by water—something like thirty miles. But on comparing these two means, one circumstance must not be lost sight of, and that is, that getting the power into the pipe in the form of compressed air, will cost twice as much as getting it in in the form of water. This is a great advantage for water where the distance is short, but where the distance is long, the greater efficiency of air more than compensates for this initial loss.

Like water, air can only be transmitted economically where the quantity is large, the friction being proportionately greater in small pipes than in large, varying as the four-fifths power of the diameter.

This is a great drawback, both as regards hydraulic and compressed air transmission. It does not affect ropes and shafts in the same way, but even in these cases considerations of durability prevent these means being used efficiently for the transmission of small quantities of power to considerable distances, so that, with the possibility already mentioned, there remains an opening for any means that will enable power to be transmitted efficiently in small quantities, and such a means we have in the flow of electricity along wires or conductors. In considering electricity, we may well start with the questions—1. Will electricity enable us to transmit power in large quantities more efficiently than the foregoing means? 2. Will it enable us to

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transmit small quantities? These questions may be more definitely answered than they could a few weeks ago. Thanks to the experiments of M. Deprez, who appears to have been the only one, out of all those who are advocating the use of electricity, who has had the courage to try and see what can be done, we can now say with certainty that a current of electricity, equivalent to five horse-power, may be sent along a telegraph wire 1-6th of an inch in diameter, some ten miles long (there and back) with an expenditure of 29 per cent. of the power, because this has already been done. In order to do this, it would seem that M. Deprez has perfected his apparatus so as to have nearly reached the possible limit. Compared with wire rope, this means falls short in actual efficiency, as Messrs. Hems send 500 horse-power along a ⅞in. rope. To carry this amount, as in the experiment of Deprez, one hundred telegraph wires would be required; these wound into a rope would make it more than 1·4in. in diameter, four times the weight of Mr. Hems's rope. With the moving rope the loss per mile is only 1·4 per cent., while with the electricity it was nearly 6; so that, as regards weight of conductor and efficiency, the electric transmission is far inferior to the flying rope. Nor is this all. With the flying belt, Mr. Hems found the loss at the ends, in getting the power into and out of the rope, 2½ per cent.; whereas, in M. Deprez's experiment, 30 per cent. was lost in the electric machinery alone, which is very small as such machinery goes. But this is not all. No account is here taken of the loss of power in the transmission to and from the electric machinery, a matter which is, I believe, very much under-estimated.

The machines made revolutions at 1,000 and 700, much too high for direct connection with either a steam-engine or any mechanical operator; the power then had at each end to be transmitted through gearing, or a system of belts. And supposing this alteration of speed to have been five or six at each end, experience tells us that a loss of at least 15 per cent. must ensue. This loss was indeed apparent, for the dynamometer was connected with the machine with a belt, which showed a loss from this one belt alone of 20 per cent. Taking the whole result, it does not appear that more than 15 or 20 per cent. of the work done by the steam engine could have been applied to any mechanical operation at the other end of the line, as against 90 per cent. which might have been realised with wire rope transmission. To set off against this, electricity has the enormous advantage in the conductor being fixed, and in the fact that it is likely to be, if anything, less costly and more efficient for small quantities of power than for large. These advantages will certainly insure a very large use for electricity in the distribution of power, particularly for high speed machinery.

There is yet another means of communicating and distributing energy now coming rapidly into vogue. This is by the transmission of coal gas along pipes. The distances, often many miles, through which the gas is often transmitted before reaching the engine, are such that, with any other means of distributing power, would considerably enhance the cost of the power. But in the case of gas it does not appear that these distances are at all a matter of consideration. This may be at once explained. It takes about ten cubic feet of gas to develop 1,000,000 foot-pounds in a gas-engine, whereas of air compressed in the ordinary way it would require something like 140 cubic feet to yield the same power. Hence the comparative cost of transmission is the cost of transmitting ten cubic feet of gas against that of 140 cubic feet of compressed air, and these would be about as one to twenty-five; so, as a means of distributing energy, gas is twenty-five times more efficient than compressed air.

I have now placed before you, as far as circumstances will allow, the various means by which energy, in a form available for power, may be transmitted over long distances, together with the circumstances which limit such transmission. By means of the railway and steamboat corn and coal can be—nay, is—transmitted half way round the earth with an expenditure of power of less than half the power represented by the coal carried, but this can only be done where the quantity to be transmitted is very large.

At present the efficiency is unrivalled, no means of packed energy or of current energy approaching even 1 per cent. And further, there is apparent room for a large diminution in the present expenditure, small as it is, in the improvement on the steam engine as a means of directing the energy of coal. For the distribution of power this means ceases to be efficient, nor can it be employed to transmit energy which has already taken the form of power. For these purposes other means have to be employed. These various means, although they differ greatly in efficiency, all fall so far below the efficiency of coal and corn, that a hundred miles appears to be the outside limit any economical transmission of power, in quantity for mechanical purposes, could be at present effected; and hence any power, be it derived from wind or water, must be used within this radius of its source; and, except in places far out of the reach of rail or water, this limit may be divided by ten.

So far as efficiency of transmission in considerable quantities, neither secondary batteries nor electrical transmission are more efficient than compressed air or belts, but when it comes to transmitting small quantities, then electric transmission has a decided advantage. The cost of the electric conductor diminishes with the quantity to be transmitted, and by making the conductor sufficiently large, its efficiency may be increased to any extent.

At the present time electric conductors are continuous half way round the world, and whenever a message is sent from England to Australia direct energy is transmitted 10,000 miles, but in what quantity? The energy of the current, as it arrives, is not much more than sufficient to keep a watch going, at any rate not more than 1-1,000 millionths of horse-power. The value of such energy, estimated at £17 per minute, would be equivalent to a billion pounds per horse-power per hour, whereas the highest price paid for animal labour in Australia or England is not more than 6d. per horse-power per hour. This shows the difference between the transmission of electricity for telegraphic purposes and its transmission for mechanical purposes. Energy differs in value greatly, but for operations that can be performed by men or horses, the price of energy must be regulated by the highest price of corn.

The prosperity of any spot in the past depended on the fertility of the adjacent soil. But the use of coal has altered this, and now the present prosperity of this country is owing to the adjacency of our coal-fields, these having rendered it possible to bring our food across the earth. The improved means of transmitting coal and corn, it would seem, have, or may again, change this, and if, instead of looking on the life of this country as limited by the life of our coal fields, we look boldly forward, and foster every means, political, social, and mechanical, which may render this a favourite spot to live upon, we need not fear that the necessity of bringing our coal from a distance will make a difference which will counterbalance the advantage we shall derive from the mechanical facilities we shall have here.

THE HAMMOND ELECTRIC LIGHT AND POWER SUPPLY COMPANY (LIMITED).

The following circular has been issued to the shareholders of this Company:—Notice is hereby given that an extraordinary general meeting of the Hammond Electric Light and Power Company (Limited) (hereinafter called the Hammond Company), will be held at the Cannon-street Hotel, situate in Cannon-street, in the City of London, on Saturday, the 10th day of November, 1883, at twelve o'clock at noon, for the purpose of considering, and (if then considered expedient) passing the following resolutions:—

1. That it is expedient to effect an amalgamation of the Yorkshire Brush Electric Light and Power Company (Limited) (hereinafter called the Yorkshire Company), with the Hammond Company.

2. That the agreement now submitted to this meeting and expressed to be made between the Yorkshire Company of the one part, and the Hammond Company of the other part, be and the same is hereby approved, and that the Board of the Hammond Company be and they are hereby authorised to carry the same into effect.

3. That it is expedient to effect an amalgamation of the Birmingham and Warwickshire Brush Electric Light and Power Company (Limited) (hereinafter called the Birmingham Company), with the Hammond Company.

4. That the draft agreement now submitted to this meeting and expressed to be made between the Birmingham Company of the one part and the Hammond Company of the other part, be and the same is hereby approved, and that the Board of the Hammond Company be and they are hereby authorised to enter into and carry the same into effect.

5. That it is expedient to effect an amalgamation of Ferranti, Thompson, and Ince (Limited) (hereinafter called the Ferranti Company), with the Hammond Company.

6. That the draft agreement now submitted to this meeting and expressed to be made between the Ferranti Company of the one part and the Hammond Company of the other part, be and the same is hereby approved, and that the Board of the Hammond Company be and they are hereby authorised to enter into and carry the same into effect.

7. That the directors of the Hammond Company be authorised to create and issue 16,000 deferred shares of the nominal value of £5 each on the terms of the agreement already approved by the Hammond Company, and authorised to be entered into and carried into effect with the Ferranti Company.

The agreements above referred to, so far as the same relate to the Yorkshire Company, and the Birmingham Company respectively, provide for the amalgamation of the two companies, the Hammond Company foregoing their rights on the shares they hold in the Yorkshire Company and Birmingham Company respectively, and also agreeing to allot and issue to the Yorkshire Company and Birmingham Company respectively for distribution amongst its shareholders fully paid up £5 shares of the Hammond Company in the proportion of one fully paid up £5 share of the Hammond Company for every six £2 fully paid up shares in the Yorkshire Company and Birmingham Company respectively.

The agreement with the Ferranti Company will provide for the amalgamation of this company with the Hammond Company in consideration of the issue to the Ferranti Company for distribution amongst its shareholders of 7,200 ordinary shares of the Hammond Company of the nominal value of £5 each, to be issued as fully paid up, and in consideration also of the like further issue to the Ferranti Company for distribution amongst its shareholders of 16,000 deferred shares, to be issued as fully paid up, of the nominal value of £5 each, and which will only be entitled to dividend

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after five per cent. has been paid on the whole of the ordinary shares of the Hammond Company.

The Yorkshire Company, the Birmingham Company, and the Ferranti Company will, for the considerations above specified, transfer to the Hammond Company all their respective undertakings, works, property, assets and effects whatsoever, the Hammond Company undertaking to bear and pay all liabilities and also the costs of all necessary agreements and of winding up and dissolving the Yorkshire Company, the Birmingham Company, and the Ferranti Company respectively, which windings up will be proceeded with voluntarily as soon as the amalgamations are carried out.

Copies of the proposed agreements referred to in the above resolutions can be seen at the offices of the solicitors of the company, Messrs. Ingledew and Ince, St. Bene't Chambers, Fenchurch-street, at any time two clear days before the day proposed for the meeting.

FAURE ELECTRIC ACCUMULATOR COMPANY (LIMITED).

An adjourned extraordinary meeting of this Company was held at the Cannon-street Hotel, on the 6th inst., under the presidency of M. E. H. Cadiot, one of the directors.

The Secretary (Mr. Herbert Canning) having read the notice convening the meeting,

The Chairman referred to the issue of a circular, which he said was sent out that morning at three o'clock, and could therefore have reached only the town shareholders. He apologised to those who had not received it, and stated that the lateness of the issue of the circular had been owing to no fault of the head office. The circular, he thought, spoke for itself, and explained the reasons of M. Philippart's absence from the meeting. They decided at a Board meeting in Paris, as late as twelve o'clock on the previous Saturday night, to put the circular before the shareholders, letting it speak for itself, and causing as little delay as possible. He wished it to be distinctly understood that the directors had been unanimously agreed on the issue of the circular, but it was most important that they should not go too much into details at present, as they were in the midst of the issue of the shares of the French Metropolitan General Electric Light Company (Limited). The issue was before the French public that day, and expressing his own personal opinion about the matter, he had the greatest faith and hope in the success of the issue. From what he knew he would almost say that he could hardly anticipate their not being taken up by the public, and according to his judgment certainly seven-eights of the issue would be subscribed for. Some time previously he attended a meeting of the shareholders, and made pretty well the same observations. As to the Board meetings having been held in Paris on a Saturday night, and their having finally settled this matter, they thought so at the time, but now it was a fact, and shares were before the public. A syndicate had been formed to defray the expenses of the issue, and they were severally and collectively concerned in its success. He had not the slightest fear, from what he knew that success would attend the issue, and if so it would mean the same for the French Electrical Company, and as the Faure Company held three-fourths of the French Company's capital it would also greatly benefit. He was perfectly satisfied that they were now absolutely on the verge of coming into port. He would be happy to answer any questions that he could answer, but he would not like to enter into too much detail, and he believed it would not be for the interest of the shareholders that too much should be said. He would put a motion before them adjourning the meeting to that day month, when they would ask the shareholders to pass the accounts, which had been left in abeyance, and he had no doubt they would do so.

Mr. Harcourt Turner protested against the course taken, and said they had the same story again about twelve o'clock Saturday night Board meetings. It appeared to him that they were only being put off month after month, and that the directors were doing all they could to avoid submitting the accounts.

Mr. Montagu Turner acquiesced in these remarks.

The Chairman stated that they were not avoiding the presentation of the accounts, but as they were not yet in a position to present them they asked for another adjournment.

Mr. Montagu Turner said that there would not only be the question of presenting the accounts to be considered, but also what the course of the Company was to be for the future.

The Chairman observed that he must ask them to wait for another month. He repeated this belief that the issue of shares referred to would be an absolute success, but they had great difficulties to contend with.

The Solicitor (Mr. Campbell), in further reply and also in answer to Mr. Jones, remarked that he supposed that one of the objects of the issue of shares by the French Company was not only to carry on their business but to meet their engagements. With regard to Mr. Turner's observations about the accounts, that of course was a matter entirely for the shareholders. The view of the Faure Company, as was the case when the late directors retired, was this—that the Faure Company were the largest shareholders in the French Company, and unless the French Company succeeded, the Faure Company, as was explained at that time, had no future before it. It appeared to him that the French Company were making every effort to place themselves in funds in order to succeed on the continent in the great work they had undertaken. He was passing through Paris some time ago, and called at the office of the Company, and found M. Philippart, who was at that time endeavouring to satisfy the French authorities as to the advantages of the accumulators, and the objects to which they might be applied. When M. Philippart was in this country he explained at the last meeting of the shareholders what he had done and what he was doing, and since then he had gone on with his experiments in France, and as far as he (the speaker) witnessed those experiments they appeared perfectly successful, especially as regarded traction power. Having satisfied the authorities in that way, M. Philippart had entered into certain very important contracts, and if he carried them out they would make the French Company a complete success, and in that case the Faure Company would reap a large proportion of the benefits accruing therefrom.

The Chairman observed that that was exactly the case.

Mr. Jones inquired whether, if the French Company were not successful, everything was not lost as regarded the Faure Company.

The Solicitor, in reply, said that he should think that in that case the Faure Company would have very little left, and that it would be in the position of the electrical companies of London.

Mr. Harcourt Turner repeated his complaint that the directors would not come before the shareholders to pass the accounts.

The Chairman warmly denied this statement, and said that they would be bound to come before the shareholders, and he repeated that he had no doubt they would pass the accounts. In every instance that he (M. Cadiot) had been before them, he had observed that Mr. Turner was antagonistic to the Board. He assured the shareholders that they were quite as anxious to further the interests of the Company as the late directors were. He thought it was better for all of them to sail in the same boat. They had been unfortunate, but he had no hesitation in saying that he was certain that the Faure Company would not be the worst of the electrical companies in the city of London. In further reply he expressed his belief that there really would be no necessity for any further adjournment.

The Solicitor testified, from personal observation, to the successful propulsion of an omnibus in Paris by means of the accumulators. M. Philippart had said he had solved the question of expense in the matter. If so, from what he (the speaker) saw, the accumulators for traction power must be a success, and if that was the case the success of the French Company was assured, and so the Faure Company would share a large amount of that prosperity.

The Chairman then moved the adjournment of the meeting to the 6th of December.

Mr. Thomas seconded the motion, which was carried, and the meeting separated.

COMPANIES' SHARE LIST.

TELEGRAPHS.

Companies.	Closing Prices Nov. 7.		Business Done Week Ending Nov. 7. Highest.	Lowest.
Anglo American	44,	45	44¼	44¼
Do. Preferred	74,	75	75¼	74¼
Do. Deferred	14½,	15½	15½	14¾
Brasil Submarine	9¼,	9¾	9¾	9 1-16
Cuba	10½,	11	11	10¾
Do. Preference	17,	18	17¾	—
Direct Spanish	5⅜,	5¾	5	—
Do. Preference	15½,	15¾	—	—
Direct United States Cable	10⅜,	10⅞	11½	10 11-16
Eastern Telegraph	10¾,	11	11	10¾
Do. 6 per Cent. Preference	13,	13½	13½	13⅛
Do. 5 per Cent. Debentures, 1899	104,	108	—	—
Eastern Extension	11⅜,	11⅞	11 13 16	11 11-16
German Union	10,	10½	—	—
Globe Telegraph and Trust Company	7,	7¼	7¾	7
Do. Preference	12⅞,	13⅛	13 1-16	12¾
Great Northern	12¾,	13⅛	13	—
Indo-European	31,	32	—	—
Mediterranean Extension	1¼,	1¾	—	—
Do. Preference	2,	4	—	—
Reuter's	8½,	9	—	—
Submarine	190,	200	190	—
West India and Panama	1,	1¼	1½	—
Do. 1st Preference	7,	7½	7¾	7½
Western Brazilian	4⅞,	5⅜	5⅛	5
West. Union 7 per Cent. 1st Mortgage	119,	121	—	—
Do. 6 per Cent. Sterling Bonds	100,	103	—	—

TELEPHONES.

Consol. Telephone and Maintenance	—,	—	¼	—
Oriental	—,	—	—	—
United Telephone	—,	—	8 5-16	8¼

ELECTRIC LIGHT.

Anglo-American Brush Lgt. (£7 paid)	2⅞,	3	3 1-16	2¾
Do. (fully paid)	4¾,	5¼	—	—
Hammond Light (£3 15s. paid)	3¼,	3½	3¾	3½
Eastern Electric (£4 paid)	¼,	¾	—	—
Swan	1½,	1¾	1 13-16	1¾
Maxim-Weston	⅛,	¾	—	—

MISCELLANEOUS.

Telegraph Construction	36,	37	36¾	36½
India Rubber, Gutta Percha, and Telegraph Works	30,	31	30¾	30½

TRAFFIC RECEIPTS FOR OCTOBER, 1883.

Companies.	Oct., 1883.	Oct., 1882.	Incrse.	Decrs.
Anglo-American Telegraph Company	—	—	—	—
Brazilian Submarine Company	—	—	—	—
Cuba Submarine Company	2,700	1,986	714	—
Direct Spanish Telegraph Company	2,111	2,079	32	—
Direct United States Cable Company	—	—	—	—
Eastern Telegraph Company	—	—	—	—
Eastern Extension Telegraph Company	36,869	29,925	6,944	—
Great Northern Telegraph Company	23,640	—	—	—
Submarine Telegraph Company	—	—	—	—
West Coast of America Telegraph Company	—	—	—	—
Western and Brazilian Telegraph Company	—	—	—	—

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